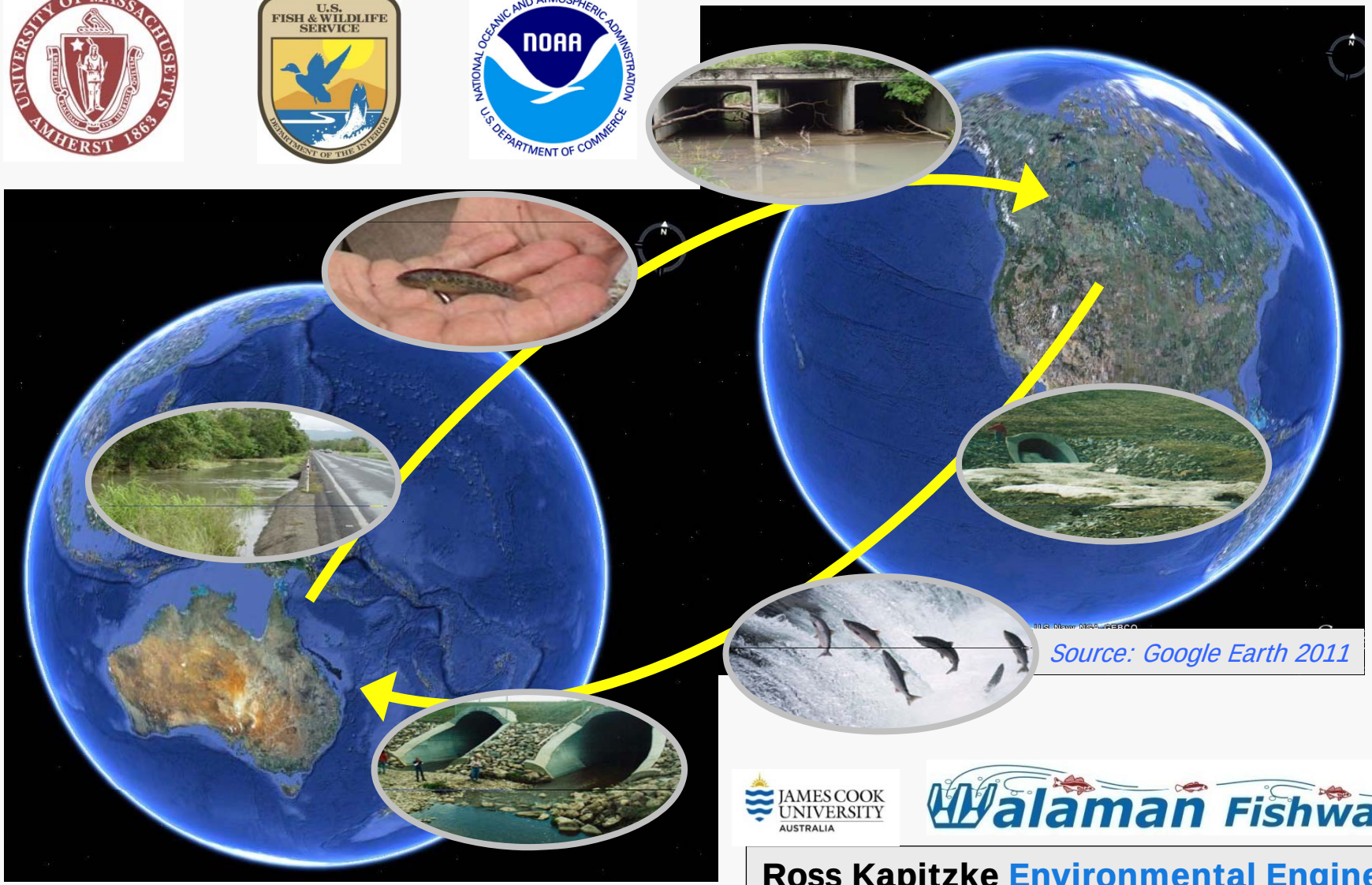
Jun 27th, 4:25 PM - 4:45 PM

Session B3- Fish Passage planning and desing for small waterway structures in Australia

Ross Kapitzke

Reconceptualising culvert fishway design for Australian waterways

Fish Passage 2011, Amherst MA



Source: Google Earth 2011

Ross Kapitzke Environmental Engineer

Aims of my talk

- Identify some universal principles for fish passage design
- Outline fish passage design features for Queensland
- Describe design and performance of fish passage projects
- Enhance international connection on fish passage design

Presentation outline

- Fish migration barriers, mitigation options, fishway types
- Fish passage R & D and protoype fishways for Queensland
- Multipurpose design for fish passage at structures
- Fishway design using *Walaman* prefabricated system
- Inter-national migration of fishway concepts – spawning / growth

Freshwater fish values

Freshwater fish spend all or part of their life cycle in freshwater environments

Commercial fisheries

Mullet

Recreational fishing

Australian bass

Conservation & biodiversity

Gudgeon

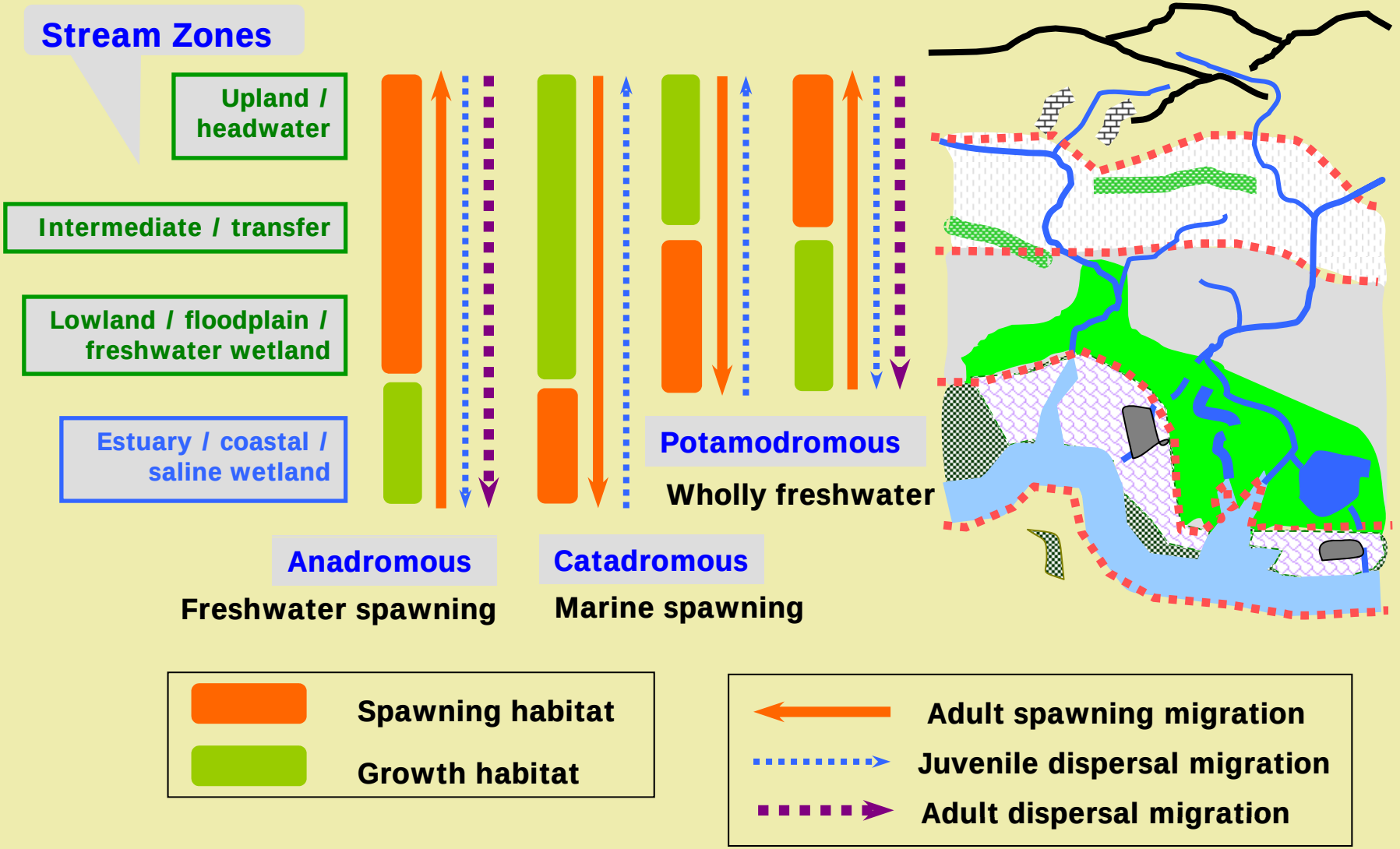
Traditional/cultural values

Long finned eel

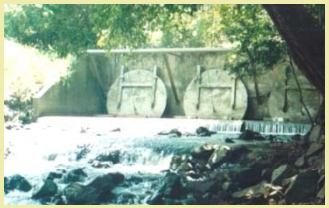
Migration requirements for freshwater fish

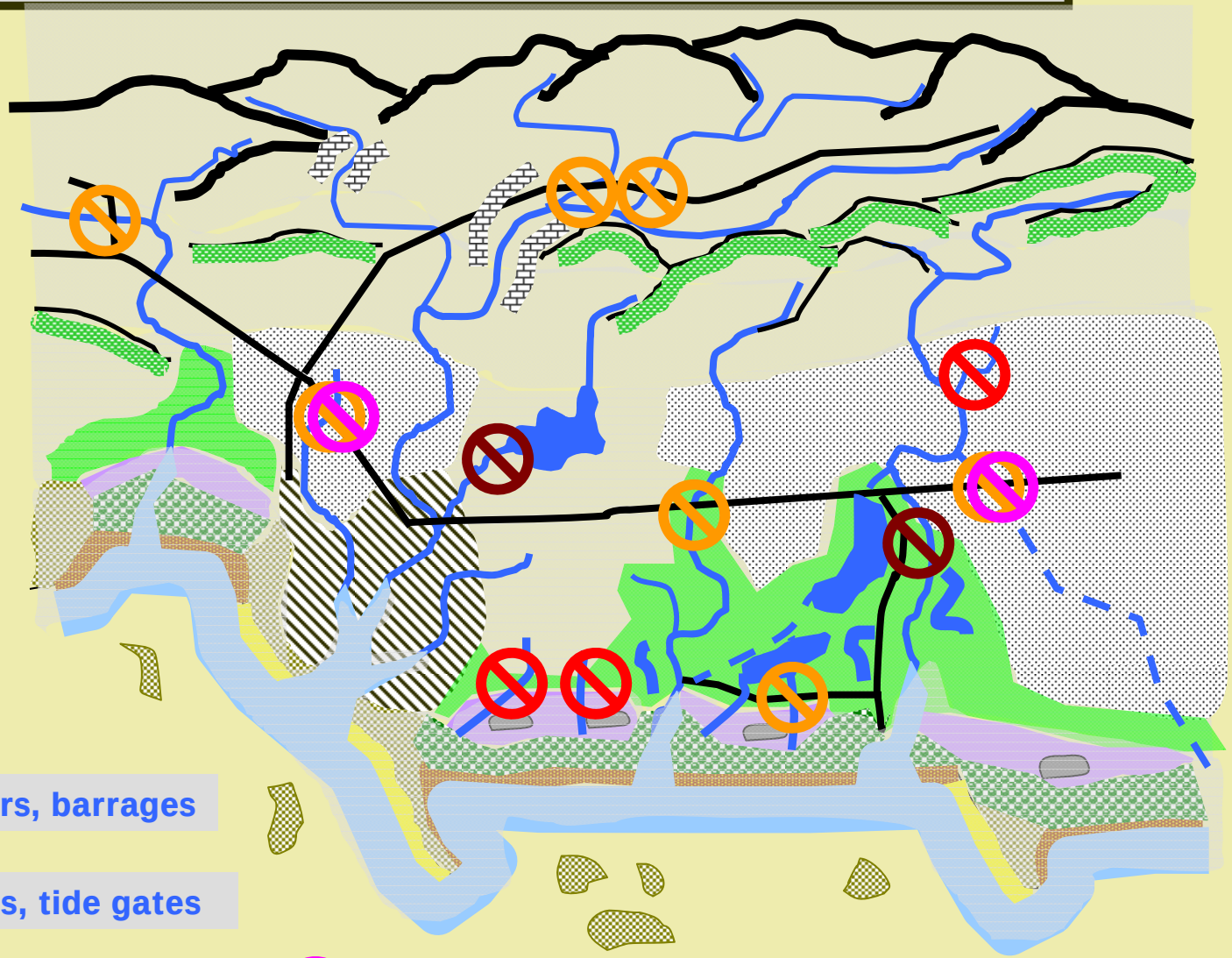
- **Life cycle stages - Spawning and growth dispersal**
- **Recolonising habitats in response to flood or drought**
- **Compensation for downstream drift**
- **Gene flow through evolutionary-scale movement**

Stream zones, fish life cycles, habitat zones & migration



Fish migration barriers in a catchment





Dams, weirs, barrages

Flood gates, tide gates

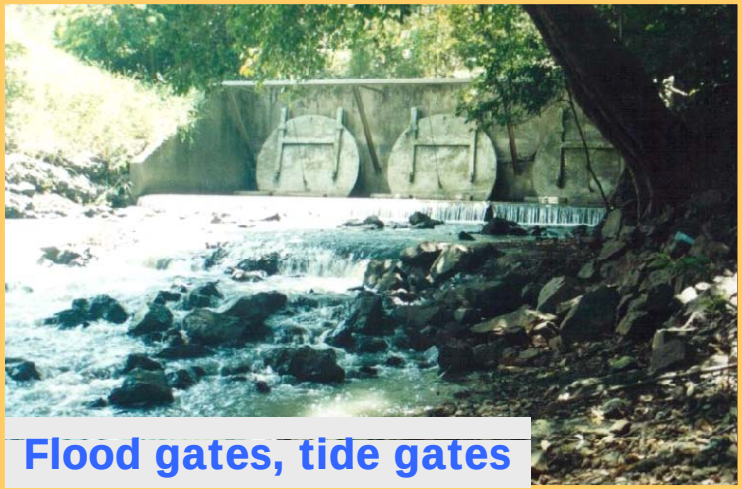
Culverts, causeways

Drop structures

Fish migration barriers – small waterway structures

Dams, weirs, barrages

Culverts, causeways



Flood gates, tide gates

Control structures, drop boards

Fish migration barriers – urban waterway structures

Weirs, barrages, grade control

Channelisation & simplification

Weed chokes

Culverts, causeways

Fish migration barrier problems – culvert inlet, outlet, barrel

water surface drop

lack of shelter

water depth

turbulence

velocity

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Establishing fish passage design for road crossings in Australia

Aquatic fauna connectivity contrasts: Northern Hemisphere & Australia

Waterway type and hydrology

- Inter-annual flow variation
- Seasonal flow variation
- Perennial / intermittent flow

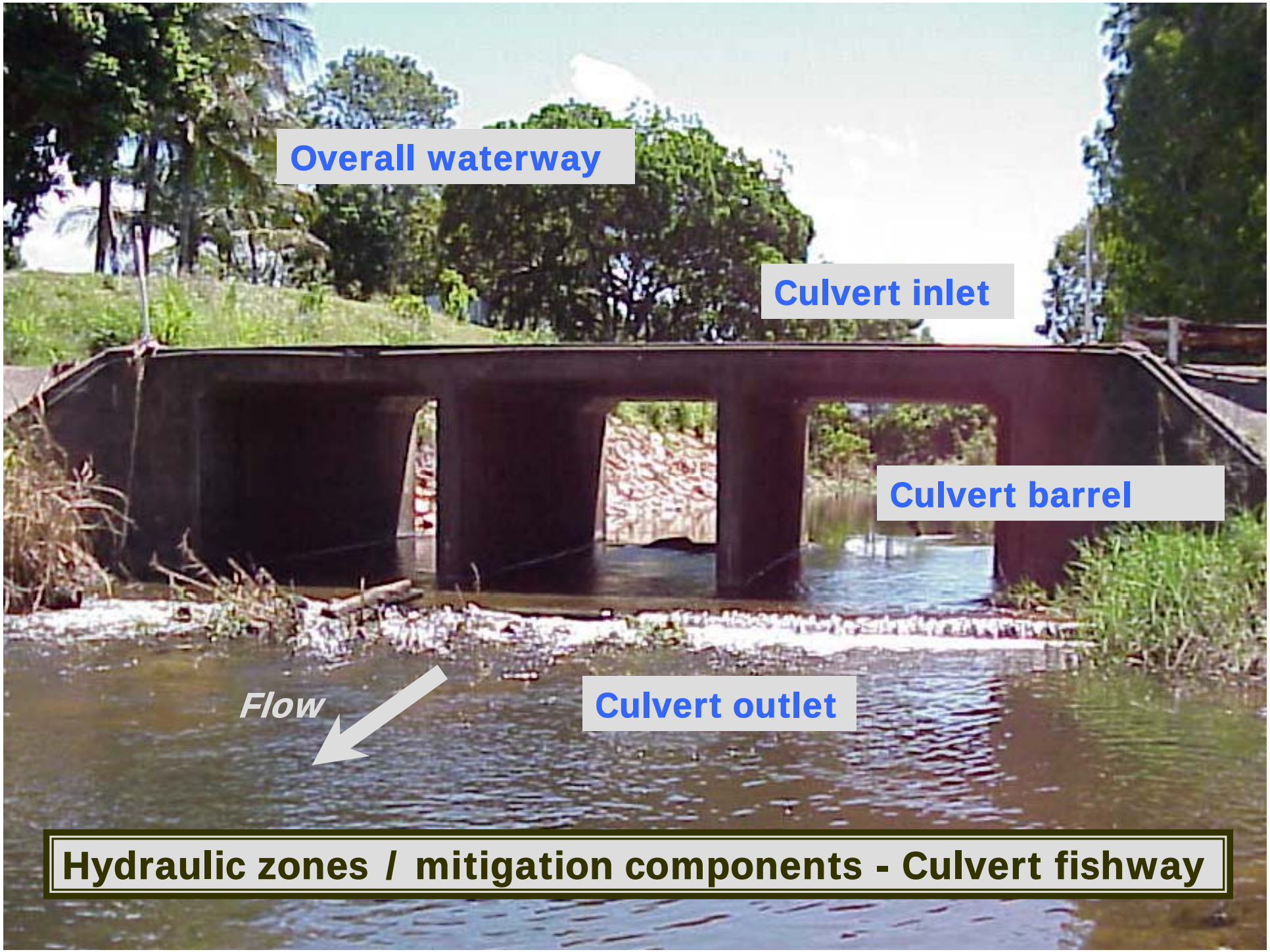
Fish species movement behaviour

- Anadromous / Catadromous
- Swim capability
- Ability to jump

Waterway crossing structure type

- Pipe culverts / box culverts
- Single cell / multi-cell

Source: Kapitzke 2010, Culvert Fishway Planning and Design Guidelines



Hydraulic zones / mitigation components - Culvert fishway

Fish passage mitigation measures for road-waterway crossings

Overall waterway

Arch culvert

Bridge

Culvert inlet, outlet & downstream

Rock ramp

Block Ramp

Apron baffles

Culvert barrel

Stream simulation

Plain culvert

Baffles – pool type

Roughness type

Fish passage design approaches for road crossings – culvert barrel

Stream simulation

Arch culvert

- » Requires equivalent channel area
- » Requires similar substrate / bed
- » Difficult to achieve for culverts

Plain culvert

Low velocity

- » Requires large cross section
- » Ponded water required for depth
- » Often larger than channel area

Hydraulic design

Baffles / Ramps / Roughness

- » Pool / roughness type fishway
- » Distinct hydraulic conditions
- » Applied to range of situations

Hybrid design

Rocks in bed

- » Difficult to configure / construct
- » Non distinct hydraulics
- » Speculative and untested

Source: Kapitzke 2002, Travelling fellowship report – Europe and North America

Why baffle fishways can still be used for culvert barrels

provide flexible solutions for range of structures / conditions

provide controlled and quantifiable hydraulic conditions.....cf. rocks in bed

impractical to achieve prolonged swim speed conditions in plain culvert ~ 0.3 m/s

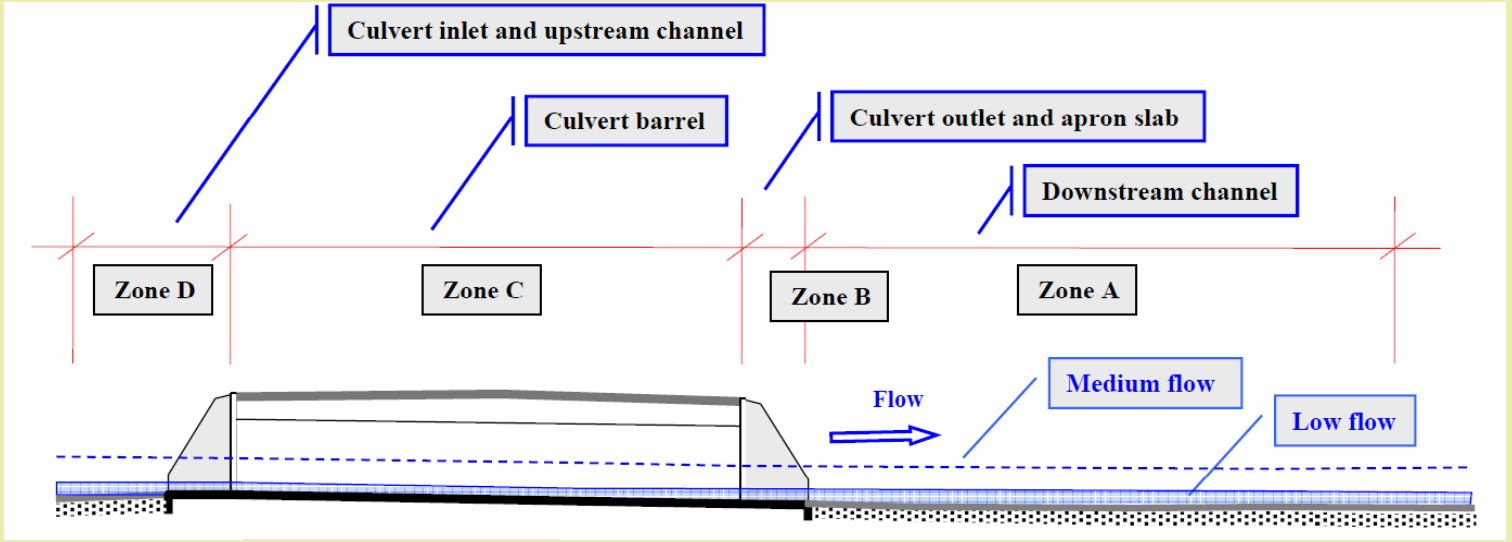
effective fish passage, flow conveyance, debris and sediment clearance

used in dedicated barrel within multiple barrel culvert facility

suited to new culverts (mitigation) or retrofits (remediation) – without removal

Typical hydraulic barriers at waterway crossing zones

Source: Kapitzke 2010, Culvert Fishway Planning and Design Guidelines



	Zone D	Zone C	Zone B	Zone A
High velocity	√	√	√	√
Flow depth	√	√	√	
No shelter	√	√	√	
Turbulence	√	√	√	√
Water drop	√		√	√

Fishway component types for culverts and open channels

After: Kapitzke 2010, Culvert Fishway Planning and Design Guidelines

Baffle fishways for box culverts

- Offset baffle fishway
- Corner “EL” baffle fishway

Baffle fishways for pipe culverts

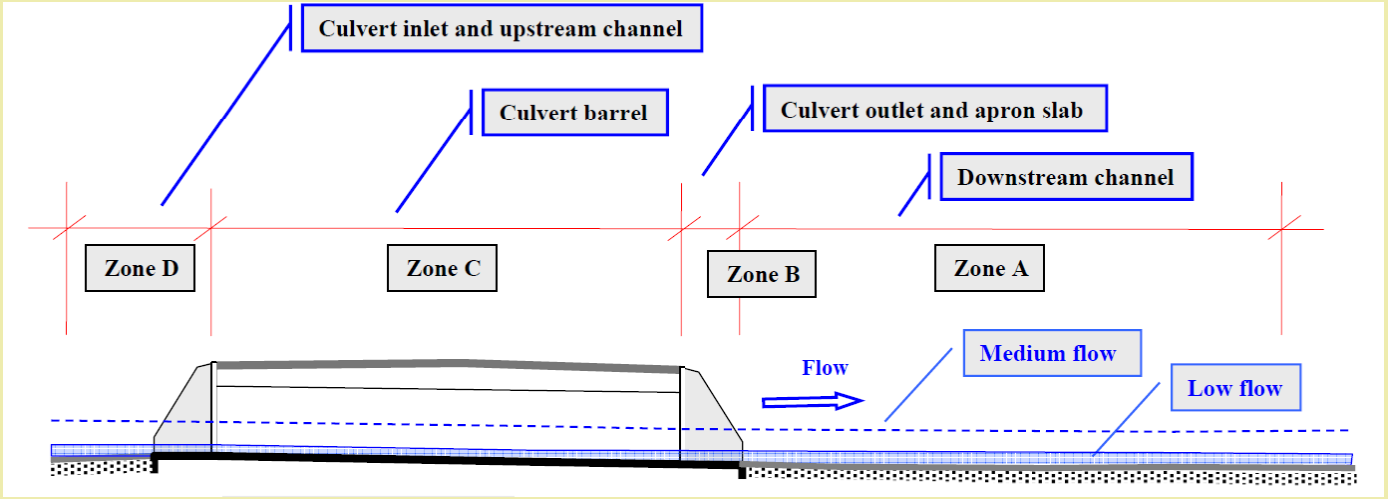
- Offset baffle fishway
- Corner “Quad” baffle fishway

Ramp fishways for drops / channels

- Rock ramp / cascade fishway
- Block ramp fishway

Application of fishway components in hydraulic zones

After: Kapitzke 2010, Culvert Fishway Planning and Design Guidelines



	Zone D	Zone C	Zone B	Zone A
Offset baffle - box	√	√	√	
Corner "EL" baffle	√	√	√	
Offset baffle - pipe		√		
Corner "Quad" baffle		√		
Rock ramp / cascade	√			√
Block ramp	√		√	√

Fish migration barriers / Fishway component types

Available at: http://www.jcu.edu.au/fishpassagedesign/

Hydraulic barriers to fish migration at waterway structures — TS01

Road crossings and other small waterway structures (e.g. culverts, causeways, grade control) may represent barriers to upstream fish migration if hydraulic conditions at the structures are more severe than swim capabilities of fish attempting to pass through. Fish migration barriers will usually occur as a result of major changes to natural waterway conditions at the structure, an d may include the following hydraulic conditions within the culvert barrel / inlet / outlet, on aprons and in channels and other hydraulic zones: high velocity; reduced flow depth; lack of resting place or shelter; excess turbulence; water surface drop.

Provisions for fish passage at road culverts and other waterway structures should address these adverse hydraulic conditions, not only within the culvert barrels, but throughout the full structure length and adjoining waterway sections, to enable fish passage through all hydraulic zones from downstream to upstream at the site.

High velocity

- culvert barrel; inlet / outlet; apron; channel
- steep gradients; uniform channels; constrictions
- velocities in structures higher than natural stream
- culverts / other structure velocities form barriers to upstream fish movement if length between rest points is greater than distance traveled by fish under prolonged or burst / rest swim modes

Shallow water depth

- culvert barrel; inlet / outlet; apron; channel
- steep gradients; wide channels; low tailwater
- flow dispersion in box culverts and on aprons
- shallow water represents a barrier to fish movement when the depth is insufficient to allow fish to swim effectively, particularly larger fish

Lack of resting place or shelter

- culvert barrel; inlet / outlet; apron
- uniform channels; lack of substrate complexity
- more severe in artificial channel than natural
- lack of resting place or shelter form barriers to upstream fish movement if length between rest points is greater than distance traveled by fish under prolonged or burst / rest swim modes

Excess turbulence

- culvert barrel; inlet / outlet; apron; channel
- steep gradients; drops; constrictions / expansions
- localised turbulence due to obstructions / debris
- fish are buffeted in turbulent flow and often lose their orientation in large scale eddies where they are unable to recognise the primary flow direction to allow them to negotiate the structure

Water surface drop

- culvert inlet / outlet; apron; downstream channel
- sudden change in channel / culvert bed
- low flow barriers may be drowned at high flows
- most Australian native fishes have very little capacity to jump and are unable to negotiate small water surface drops

Common occurrence of principal hydraulic barriers to fish migration within particular zones of culverts / waterway structures

Hydraulic barrier type	Zone D: Culvert inlet and upstream channel	Zone C: Culvert barrel	Zone B: Culvert outlet & downstream apron	Zone A: Downstream channel
High velocity	✓	✓	✓	✓
Shallow water depth	✓	✓	✓	
Lack of resting place	✓	✓	✓	
Excess turbulence	✓	✓	✓	✓
Water surface drop	✓		✓	✓

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Fishway component types for small waterway structures — TS02

The configuration of fish passage facilities at a waterway structure is established on the basis of fish migration barrier characteristics of the structure and fish passage goals and other multipurpose requirements for the site. A number of fishway configuration options comprising several component types may be considered to overcome migration barriers within various hydraulic zones of the structure.

Offset Baffle fishway – Box culverts, aprons and channels

- series of low baffles fixed to structure base
- suited to relatively shallow high velocity flow
- less suited to deep slow water environments
- provides low velocity / shelter / flow circulation for flows within and surcharging the baffles
- good self-cleaning and through-flow attributes

Corner "EL" Baffle fishway – Box culverts

- series of "L" shaped baffles perpendicular to wall
- suited to relatively deep low velocity flow
- less suited to shallow high velocity flow
- provides flow resistance / shelter / recirculation within baffle field for full height of baffles
- good self-cleaning and through-flow attributes

Offset Baffle fishway – Pipe culverts

- series of low baffles fixed to structure base
- suited to relatively shallow high velocity flow
- less suited to deep slow water environments
- provides low velocity / shelter / flow circulation for flows within and surcharging the baffles
- less suited to pipe culverts than to box culverts

Corner "Quad" Baffle fishway – Pipe culverts

- series of quad baffles perpendicular to wall
- suited to relatively deep low velocity flow
- more readily constructed than offset baffle
- provides flow resistance / shelter / recirculation within baffle field for full height of baffles
- good self-cleaning and through-flow attributes

Rock Ramp fishway – Open channels

- series of transverse rock ridges with small pools
- localised drops ranging from 50 mm to 100 mm
- suited for free standing or attached structures
- provides low velocity zones / shelter areas for flows within and surcharging the rock ridges
- multiple interconnected pathways for fish passage

Block Ramp fishway – Weirs, grade control, aprons and drops

- series of transverse ridge V-slots with small pools
- localised drops ranging from 50 mm to 100 mm
- suited for weirs, grade control, aprons or drops
- provides low velocity zones / shelter areas for flows within and surcharging the block ridges
- suited for use in fishway system with offset baffle

Possible application of fishway component types for particular hydraulic zones of culverts / waterway structures

Fishway component type	Zone D: Culvert inlet and upstream channel	Zone C: Culvert barrel	Zone B: Culvert outlet & downstream apron	Zone A: Downstream channel
Offset Baffle – Box	✓	✓	✓	
EL Baffle – Box	✓	✓	✓	
Offset Baffle – Pipe		✓	✓	
Quad Baffle – Pipe		✓		
Rock Ramp – Open ch	✓			✓
Block Ramp – Drop	✓		✓	✓

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Fish passage design flow conditions – Waterway structures

Low flow

- Flow depth < ~ 0.5 m
- Inundating channel bed

Medium flow

- 0.5 m < flow depth < ~ 1.5 m
- Below low flow channel bench

High flow

- 1.5 m < flow depth
- Upper channel / overbank flow

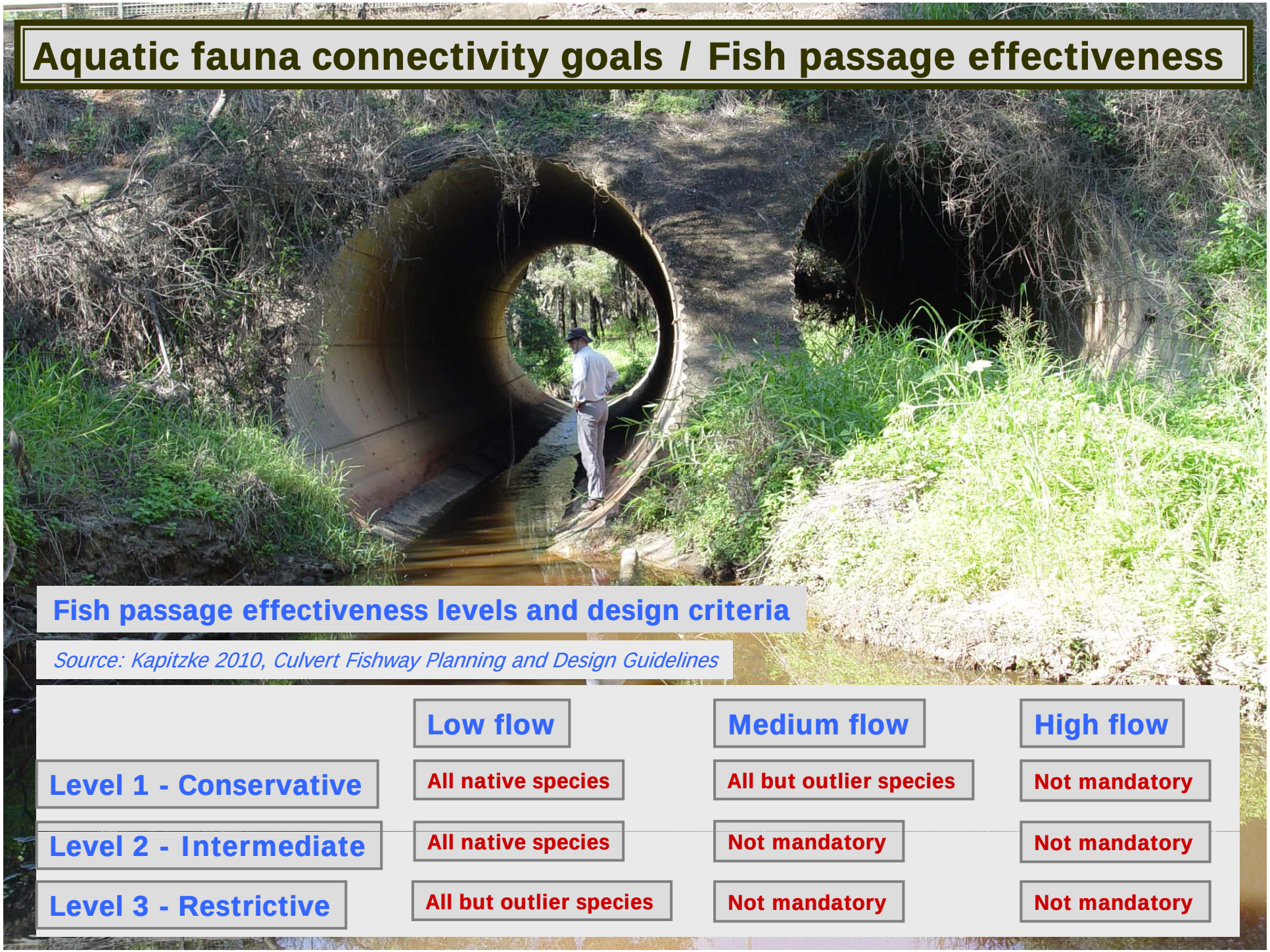
Nominal fish swim speeds – typical design conditions

Source: Kapitzke 2010, Culvert Fishway Planning and Design Guidelines

Source: Kapitzke 2007, Bruce Highway Corduroy Creek to Tully fish passage road corridor scale assessment

Fish size range	Prolonged speed (20 sec to 200 min duration)	Burst speed (5 to 20 sec duration)
AUS – Adult upstream spawning migration		
Medium size fish species (adults 15 cm - 25 cm)	0.45 m/s to 0.75 m/s	0.9 m/s to 1.5 m/s
Small size fish species (adults < 10 cm)	0.25 m/s	0.5 m/s
JUD – Juvenile upstream dispersal migration		
Medium – large size fish species (juveniles to 30 cm)	0.3 m/s to 1.0 m/s	up to 1.4 m/s
Small size fish species (juveniles to 10 cm)	0.1 m/s to 0.3 m/s	0.2 m/s to 0.6 m/s

Aquatic fauna connectivity goals / Fish passage effectiveness



Fish passage effectiveness levels and design criteria

Source: Kapitzke 2010, Culvert Fishway Planning and Design Guidelines

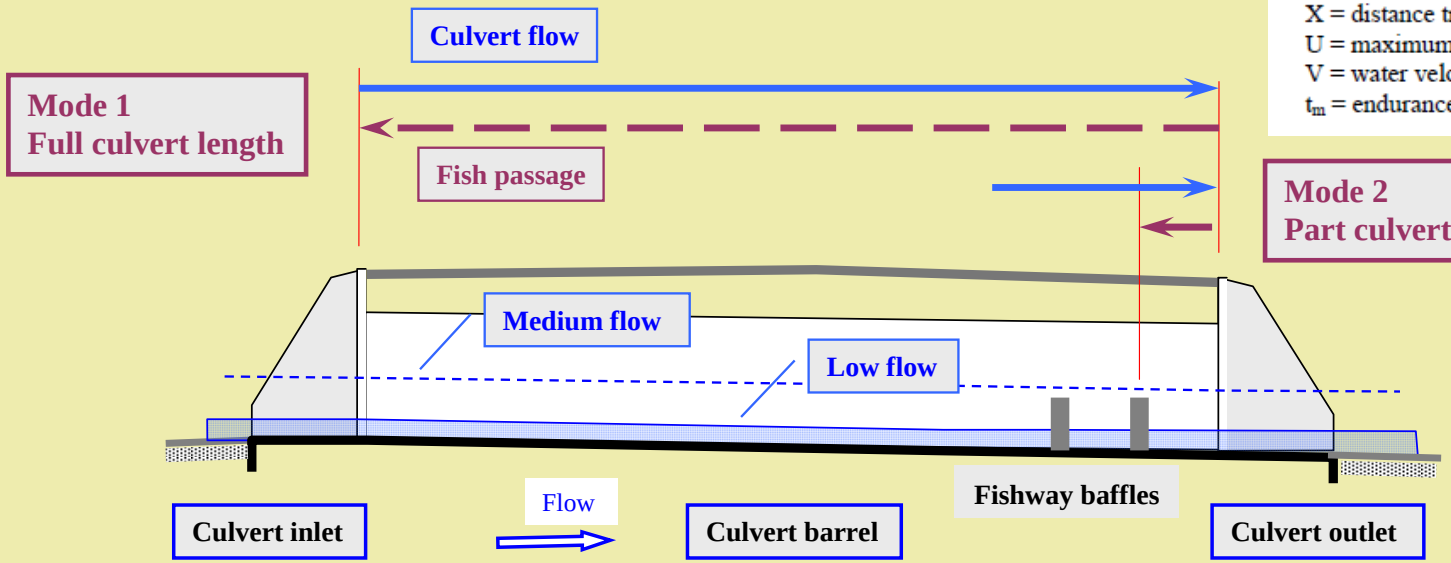
	Low flow	Medium flow	High flow
Level 1 - Conservative	All native species	All but outlier species	Not mandatory
Level 2 - Intermediate	All native species	Not mandatory	Not mandatory
Level 3 - Restrictive	All but outlier species	Not mandatory	Not mandatory

Example: Velocity barrier – Fish swim modes and swim speeds

Source: Kapitzke 2010, Culvert Fishway Planning and Design Guidelines

$X = (U - V)\ t_m$

X = distance travelled (m)
U = maximum swimming speed of fish
V = water velocity (m/s)
t_m = endurance time (secs)



Required swim speed for fish to negotiate culvert – full or partial length

Culvert velocity	Mode 1 – full length (15 m)		Mode 2 – baffles (wall / floor)
	Prolonged speed	Burst speed	Prolonged / burst speed
0.3 m/s	~ 0.3 m/s	1.05 m/s	~ 0.3 m/s
0.6 m/s	~ 0.6 m/s	1.35 m/s	< 0.6 m/s (depends on baffle type)
0.9 m/s	~ 0.9 m/s	1.65 m/s	< 0.9 m/s (depends on baffle type)

Prolonged speed – maintained for 20 sec to 200 min

Burst speed – maintained for 5 to 20 sec

Prototype fishway design, development and testing

University Creek, Townsville, north Queensland, Australia

Prototype #1 Discovery Drive offset baffle fishway

Prototype #2 Douglas Arterial Project rock ramp fishway

Prototype #3 Solander Road pipe culvert fishway

Prototype #4 Discovery Drive corner baffle fishway

University Ck fish community – *13 native species observed in 2003*

Long-finned eel

Black catfish

Agassiz's glassfish

Spangled perch

Hyrtl's tandan

Barred Grunter

Empire gudgeon

Purple spotted gudgeon

Eastern rainbowfish

University Creek Discovery Drive prototype culvert fishways

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Prototype #4 – Corner "EL" baffle

Prototype #1 – Offset baffle

Offset baffle fishway for box culverts

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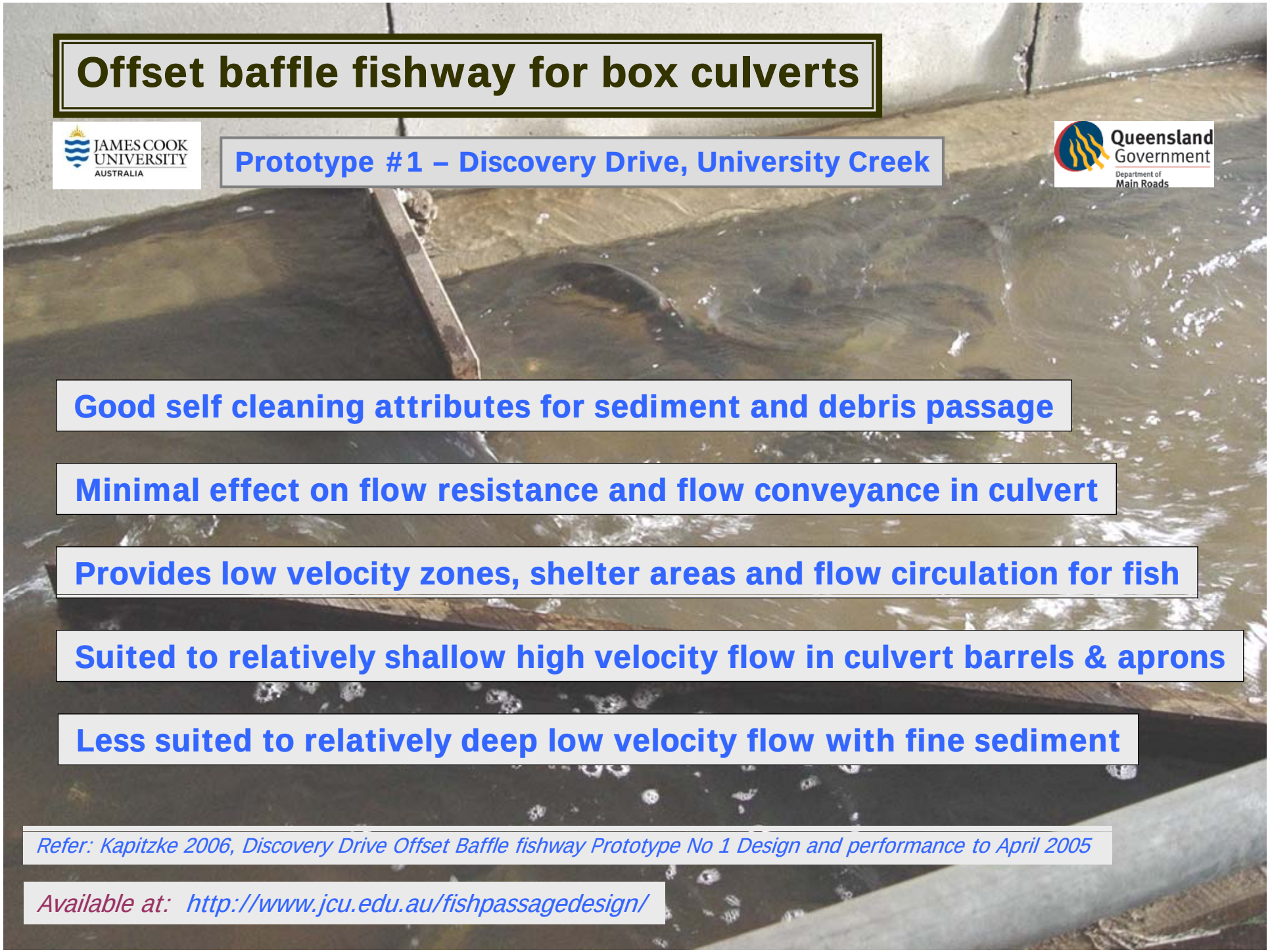
Prototype #1 – Discovery Drive, University Creek

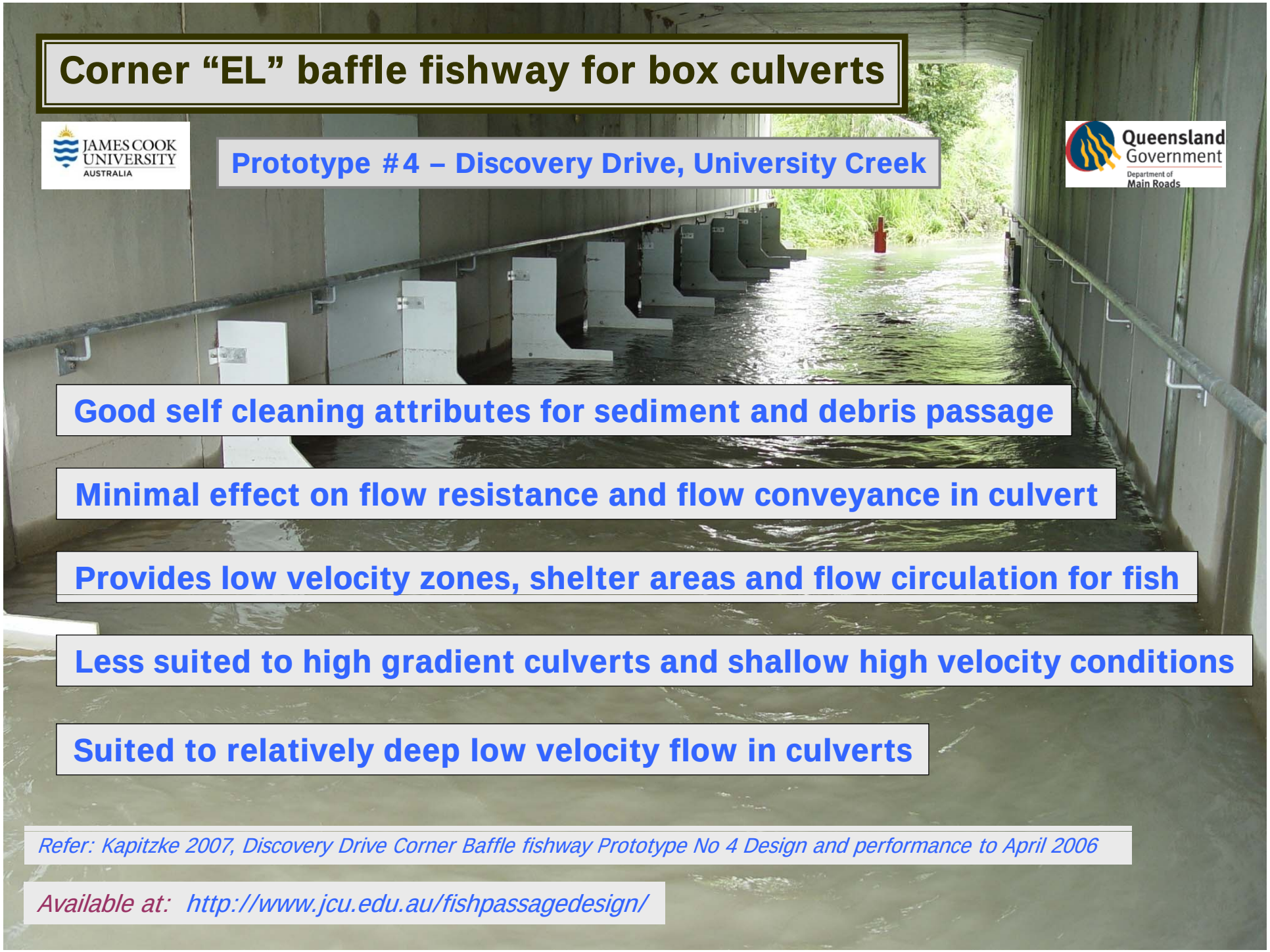


- Good self cleaning attributes for sediment and debris passage
- Minimal effect on flow resistance and flow conveyance in culvert
- Provides low velocity zones, shelter areas and flow circulation for fish
- Suited to relatively shallow high velocity flow in culvert barrels & aprons
- Less suited to relatively deep low velocity flow with fine sediment

Refer: Kapitzke 2006, Discovery Drive Offset Baffle fishway Prototype No 1 Design and performance to April 2005

Available at: http://www.jcu.edu.au/fishpassagedesign/

Corner “EL” baffle fishway for box culverts



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Prototype #4 – Discovery Drive, University Creek

Good self cleaning attributes for sediment and debris passage

Minimal effect on flow resistance and flow conveyance in culvert

Provides low velocity zones, shelter areas and flow circulation for fish

Less suited to high gradient culverts and shallow high velocity conditions

Suited to relatively deep low velocity flow in culverts

Refer: Kapitzke 2007, Discovery Drive Corner Baffle fishway Prototype No 4 Design and performance to April 2006

Available at: http://www.jcu.edu.au/fishpassagedesign/

Corner “Quad” baffle fishway for pipe culverts

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Prototype #3 – Solander Road, University Creek

Queensland Government Department of Main Roads

- Good self cleaning attributes for sediment and debris passage
- Minimal effect on flow resistance and flow conveyance in culvert
- Provides low velocity zones, shelter areas and flow circulation for fish
- Less suited to high gradient culverts and shallow high velocity conditions
- Suited to range of flow depths, including relatively deep low velocity flow

Refer: Kapitzke 2007 Solander Road pipe culvert fishway Prototype No 3 Design and performance to April 2006

Available at: http://www.jcu.edu.au/fishpassagedesign/

Rock ramp fishway for open channels

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Prototype #2 – Douglas Arterial Road, University Creek

- **Good self cleaning attributes for sediment and debris passage**
- **Little obstruction to flow and little effect on flow conveyance**
- **Provides passage for variety of fish species at range of stream flows**
- **Provides low velocity zones and multiple connected pathways for fish**
- **Suited as free standing grade control or attached to culvert inlet or outlet**
- **Nature like fishways used to overcome water surface drops in streams**

Refer: Kapitzke 2006 Douglas Arterial Project rock ramp fishway Prototype No 2 Design and performance to April 2005

Available at: http://www.jcu.edu.au/fishpassagedesign/

Rock ramp cascade fishway for open channels

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Prototype #3 – Solander Road, University Creek

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Refer: Kapitzke 2007 Solander Road pipe culvert fishway Prototype No 3 Design and performance to April 2006

Available at: http://www.jcu.edu.au/fishpassagedesign/

Convergence of goals: Waterways / Stormwater / Aquatic connectivity

Evolution of values and goals

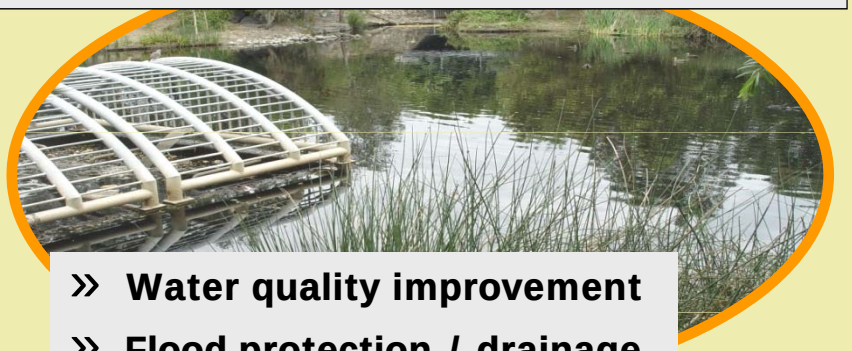
Drainage / utility

Multiple goals

Waterway management

- » Flooding / erosion / utility
- » Habitat / biodiversity
- » Stream process / water quality
- » Operation, safety & amenity

Stormwater management / WSUD



- » Water quality improvement
- » Flood protection / drainage
- » Habitat enhancement
- » Amenity & recreation values

Aquatic fauna connectivity

- » Fish passage
- » Drainage, utility, stream integrity
- » Stream processes / environment
- » Operation, safety & amenity

Values and goals: Stream management / Waterway enhancement

Flooding / erosion / utility

Habitat / biodiversity

Stream process / water quality

Operation / amenity

Values and goals: Stormwater management / WSUD

Water quality improvement

Flood protection / drainage

Habitat enhancement

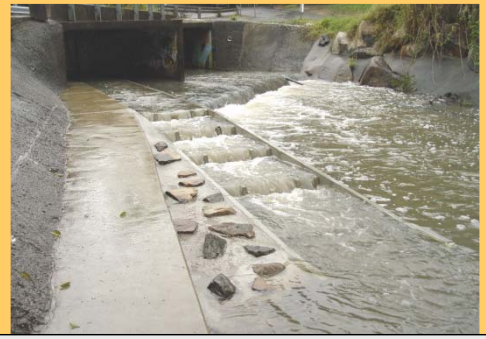
Amenity / recreation

Values and goals: Aquatic fauna connectivity / fish passage

Fish passage

Drainage / utility

Stream process / environ.



Operation / amenity

Fish passage design for waterway structures – Multiple objectives

After: Kapitzke 2010, Culvert Fishway Planning and Design Guidelines

Fish passage

- Provide for fish passage over range of fish migration flows in the stream
- Provide suitable hydraulic conditions for fish – velocity, flow depth…
- Provide flow continuity, fish pathway, attraction flows and exit conditions
- Ensure adequate light and other suitable environmental conditions

Drainage

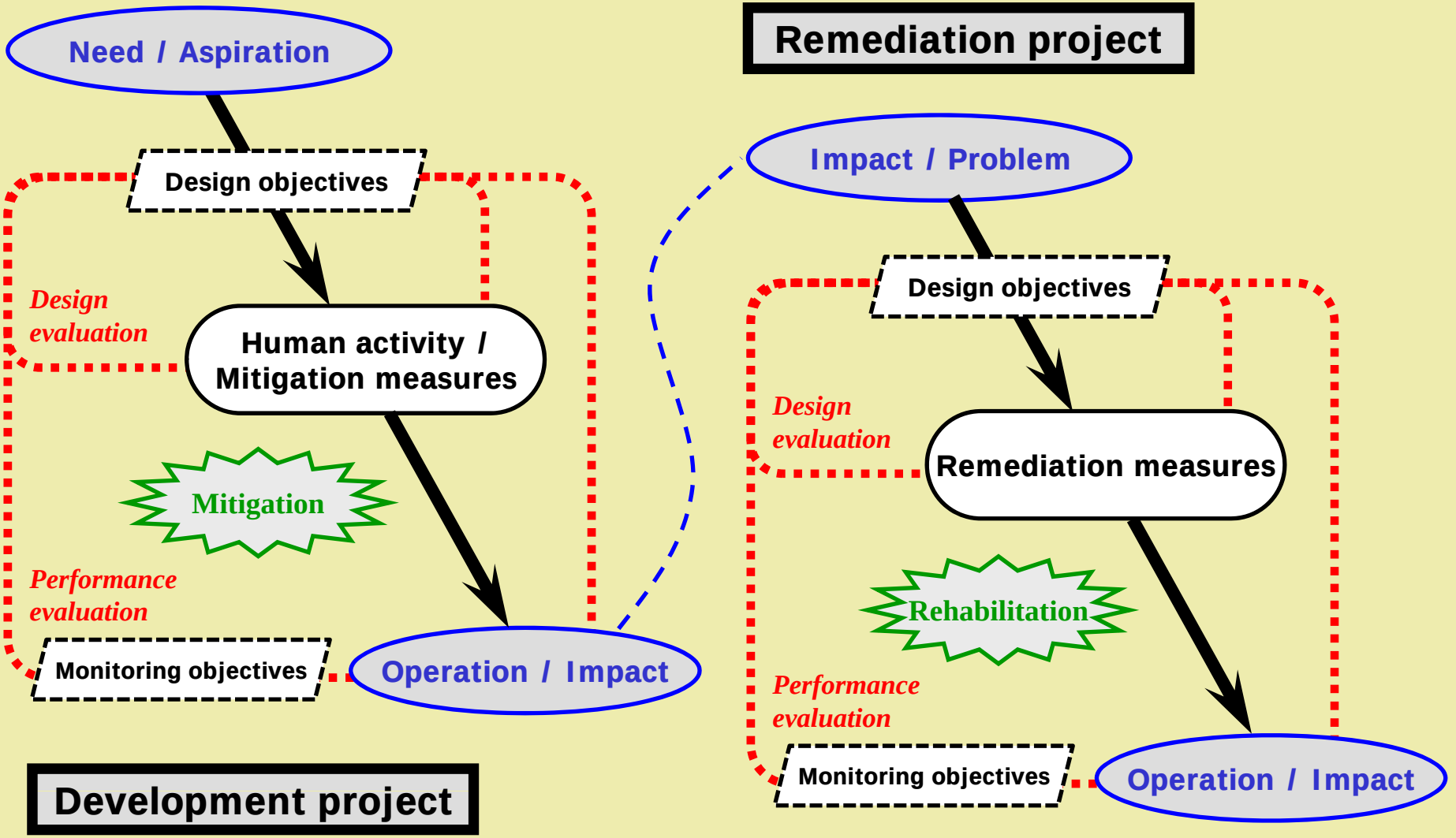
Environment

Amenity

- Minimise obstruction to flow to not adversely affect flooding / drainage
- Minimise effects of debris accumulation and sediment deposition
- Prevent flood / erosion damage & maintain structure / waterway integrity
- Maintain natural flow regime, geomorphic and ecological processes
- Protect riparian and instream habitat and provide for fauna connectivity
- Provide for monitoring, access and maintenance of fishway facility
- Avoid public health problems, provide for safety, maintain amenity

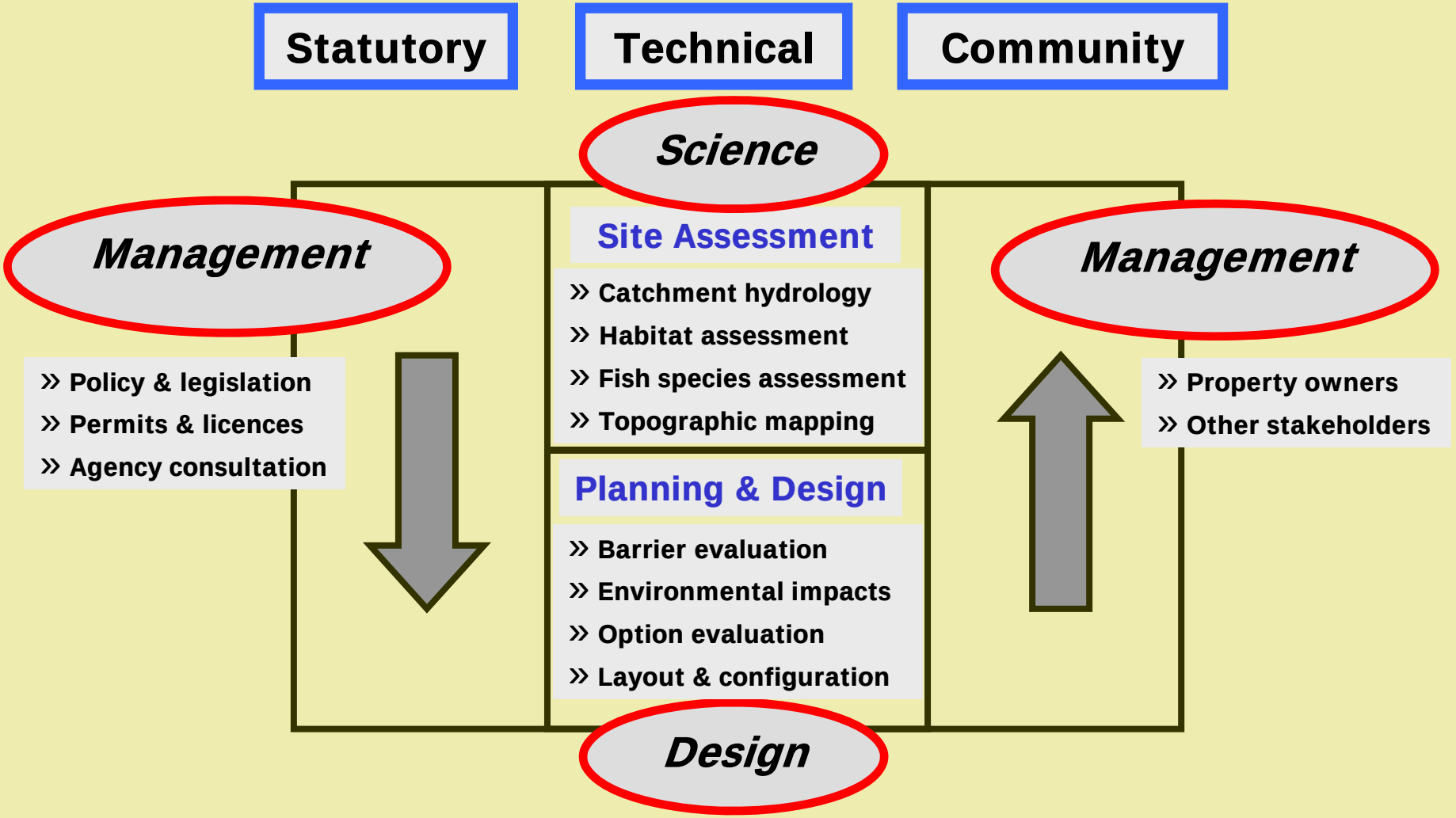
Impact mitigation: Design evaluation / performance evaluation

After: Kapitzke 2003, Proceedings of the National Environment Conference, Brisbane, 18-20 June 2003



Mitigation design: Statutory, community and technical framework

After: Kapitzke 2003, Proceedings of the National Environment Conference, Brisbane, 18-20 June 2003



Key point – Mitigation design integrates ecological and engineering solutions

Enoggera Creek Bennett Road – Culvert fishway project

Available at: http://www.youtube.com/walamanfishways

Objectives

- Improve aquatic fauna connectivity for Enoggera Creek system
- Establish prototype fishways for typical urban waterway structures
- Provide fish passage demonstration sites for community and practitioners

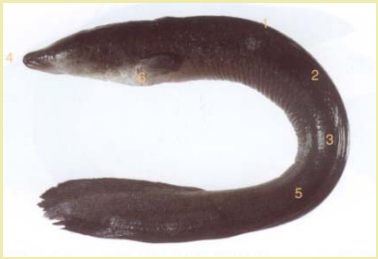
Scope of work

- Aquatic habitat and connectivity assessment for Enoggera Creek reaches
- Fish migration barrier assessment and evaluation of mitigation options
- Design, fabrication and installation of fishway facilities
- Hydraulic and biological monitoring and evaluation of fishways

Freshwater fish community – Enoggera Creek

Native freshwater species (> 10)

- eels (2)
- catfish
- glass perch
- gudgeon (4)
- rainbowfish
- hardyhead (2)
- Australian smelt



Translocated freshwater species (1)

- Queensland lungfish

Exotic species (4)

- Gambusia, Platy, Swordtails, Guppy

Bennett Road culvert fishway – Barriers to fish migration

(Source: Ross Kapitzke 01/10/06)

(Source: Ross Kapitzke 08/12/07)

(Source: Ross Kapitzke 18/11/08)

(Source: Ross Kapitzke 19/11/08)

Bennett Road culvert: Barriers to upstream migration

D – Culvert inlet & upstream channel

Low flow

» Velocity ~ 0.6 m/s
» Shallow flow

Medium flow

» Velocity ~ 1.5 m/s
» Lack of shelter

A – Downstream channel

Low flow

» Vel ~ 1.0 m/s
» Drop 0.2 – 0.6 m

Medium flow

» Vel ~ 2.0 m/s
» Drop nil – 0.2 m

C - Culvert barrel

Low flow

» Vel ~ 1.5 m/s
» Shallow flow

Medium flow

» Vel ~ 2.5 m/s
» Lack of shelter

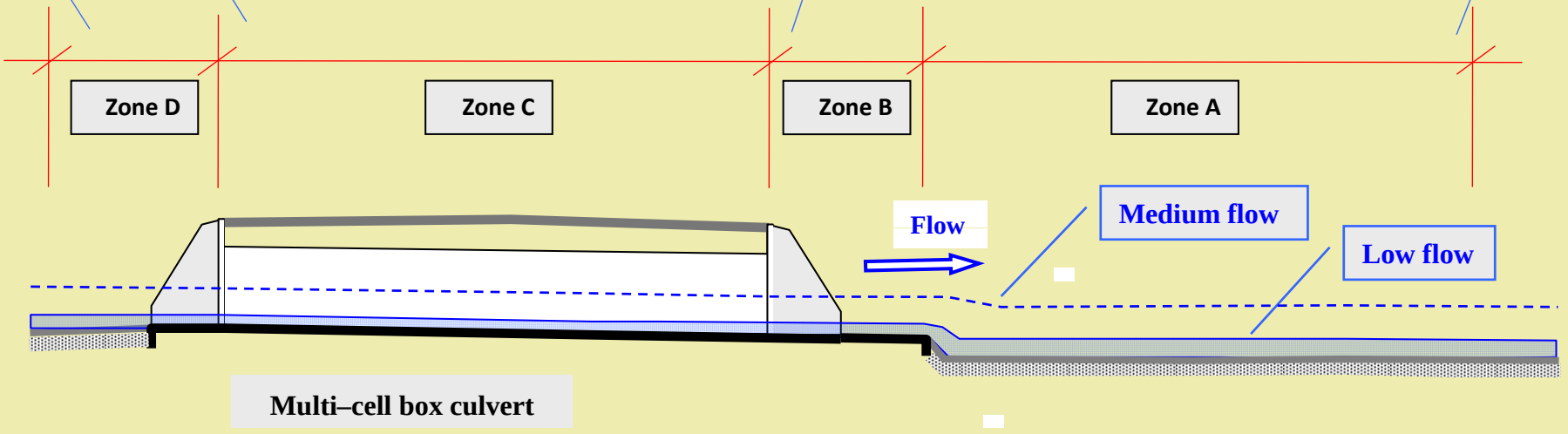
B - Culvert outlet & apron slab

Low flow

» Vel ~ 2.5 m/s
» Shallow flow

Medium flow

» Vel ~ 4.0 m/s
» Lack of shelter



Multi–cell box culvert

Bennett Road culvert: Fish passage design requirements

Source: Kapitzke 2010 Enoggera Creek Bennett Road culvert provisions for fish passage summary design report

D – Culvert inlet & upstream channel

V = …0.6 m/s (low flow)

- » Provide suitable velocity / depth / shelter conditions
- » Provide upstream shelter

A – Downstream channel & drop-off

Drop = 0.2 – 0.6 m (low flow)

- » Provide suitable tailwater levels / drops
- » Ensure adequate shelter
- » Provide attraction flows

C - Culvert barrel

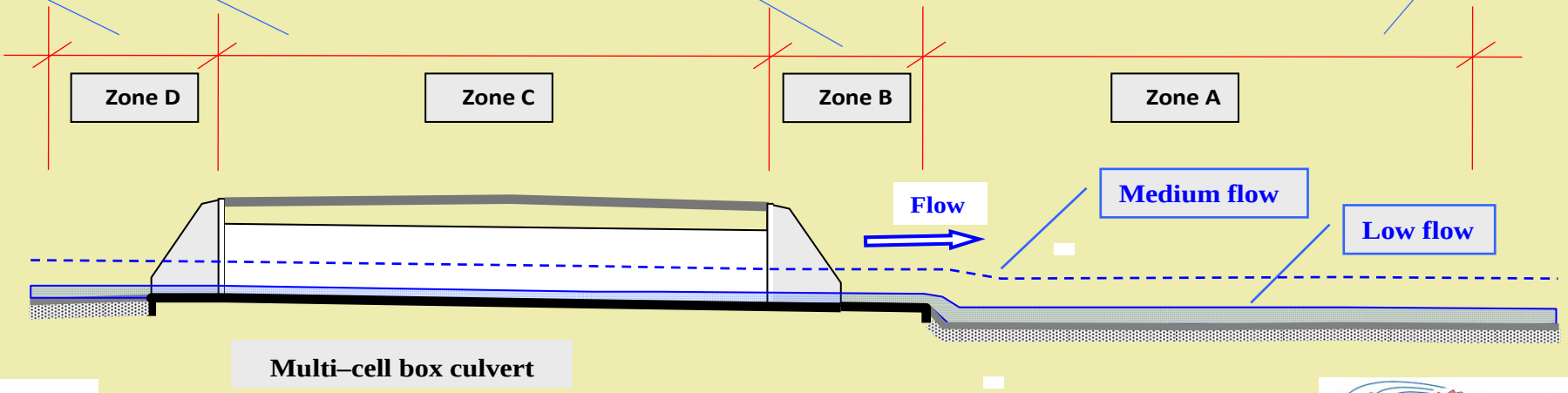
V = …1.5 m/s (low flow)

- » Provide suitable velocity / depth / shelter conditions
- » Provide flow continuity

B - Culvert outlet & apron slab

V = …2.5 m/s (low flow)

- » Provide suitable velocity / depth / shelter conditions
- » Provide flow continuity, attraction flows



Multi–cell box culvert

Fish passage design for waterway structures – Multiple objectives

After: Kapitzke 2010, Culvert Fishway Planning and Design Guidelines

Fish passage

- Provide for fish passage over range of fish migration flows in the stream
- Provide suitable hydraulic conditions for fish – velocity, flow depth…
- Provide flow continuity, fish pathway, attraction flows and exit conditions
- Ensure adequate light and other suitable environmental conditions

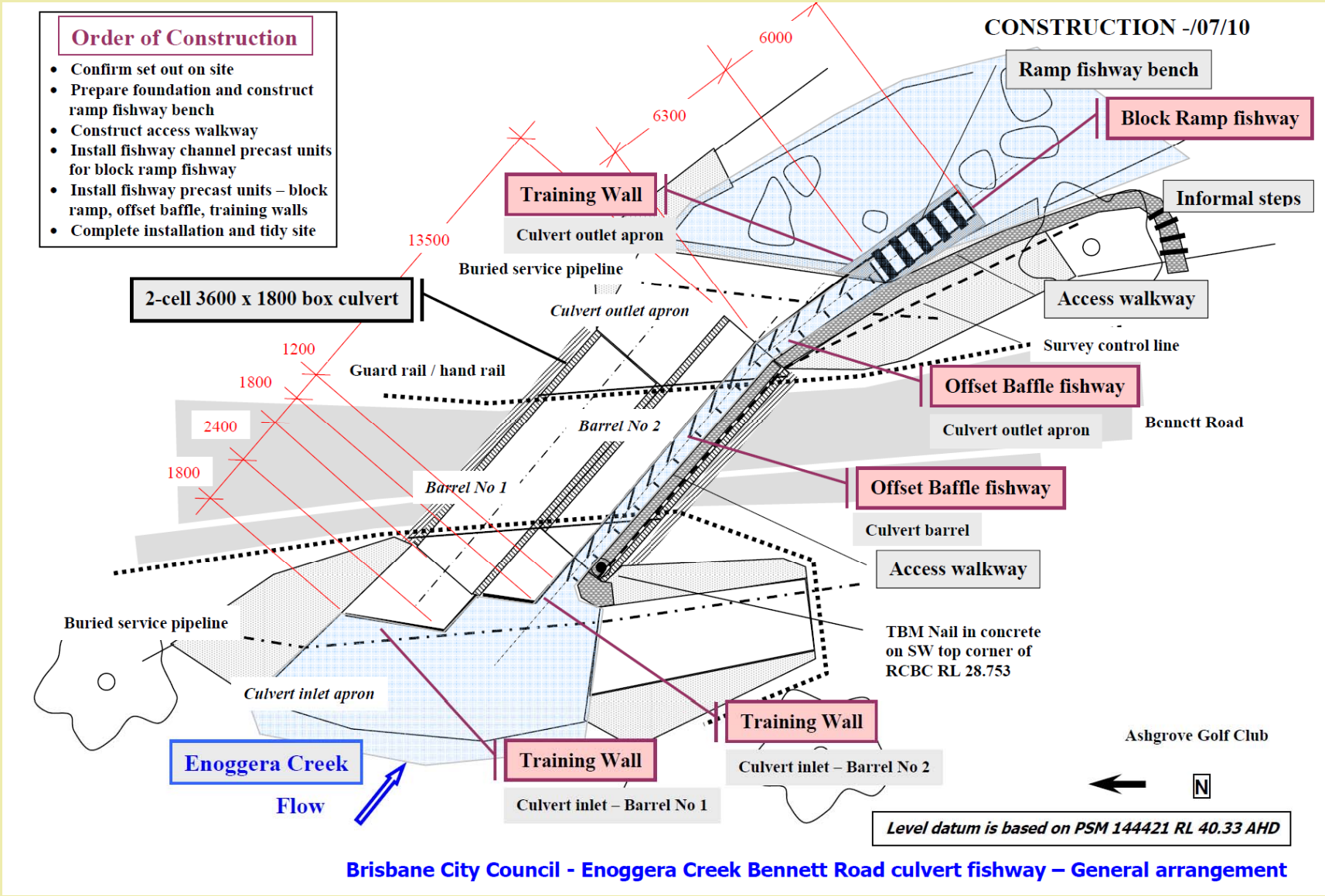
Drainage

Environment

Amenity

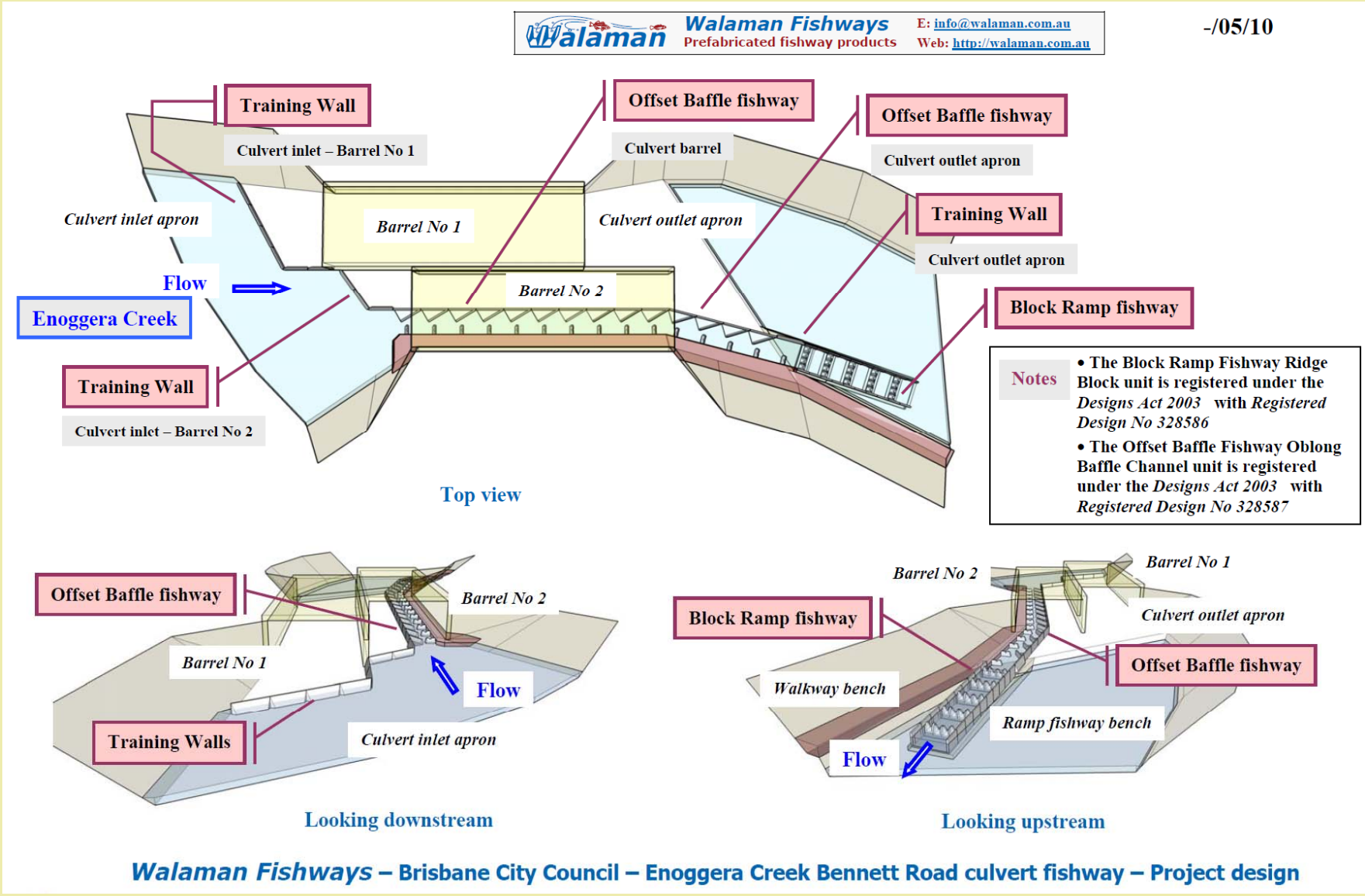
- Minimise obstruction to flow to not adversely affect flooding / drainage
- Minimise effects of debris accumulation and sediment deposition
- Prevent flood / erosion damage & maintain structure / waterway integrity
- Maintain natural flow regime, geomorphic and ecological processes
- Protect riparian and instream habitat and provide for fauna connectivity
- Provide for monitoring, access and maintenance of fishway facility
- Avoid public health problems, provide for safety, maintain amenity

Bennett Road culvert fishway: General arrangement



Brisbane City Council - Enoggera Creek Bennett Road culvert fishway – General arrangement

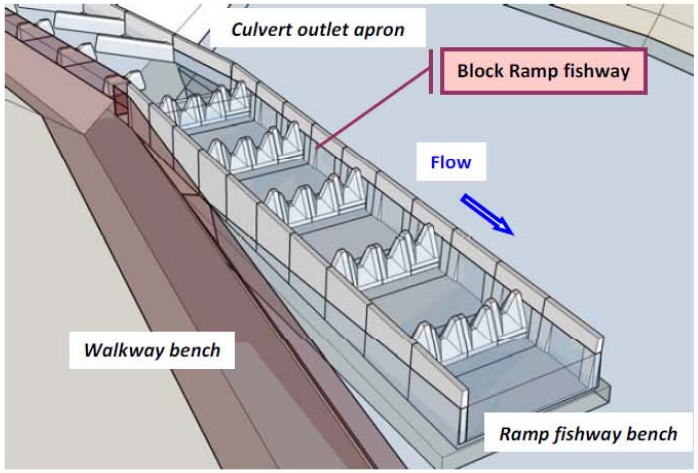
Bennett Road culvert fishway: Assembly



Bennett Road culvert fishway: Scene sequence – Outlet drop

(Source: Ross Kapitzke 08/12/07)

(Source: James Cook University 2010)



(Source: Ross Kapitzke 13/04/10)

(Source: Ross Kapitzke 05/05/10)

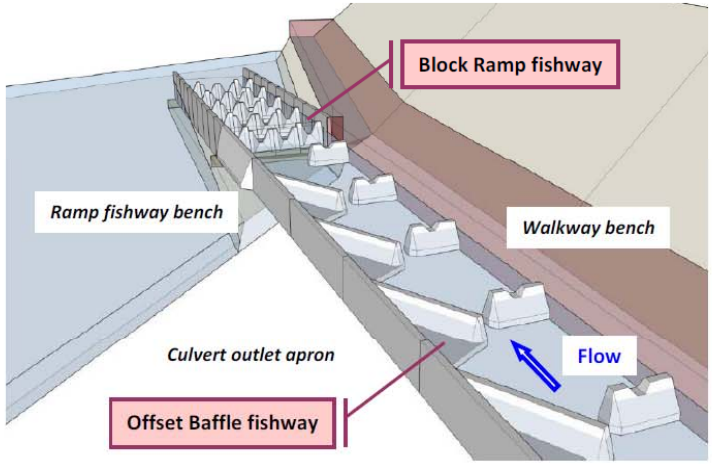
Walaman Fishways
Prefabricated fishway products
E: info@walaman.com.au
Web: http://walaman.com.au

Walaman Fishways – Brisbane City Council – Enoggera Creek Bennett Road culvert – Scene sequence – Outlet drop

Bennett Road culvert fishway: Scene sequence – Culvert apron

(Source: Ross Kapitzke 08/12/07)

(Source: James Cook University 2010)



(Source: Ross Kapitzke 19/04/10)

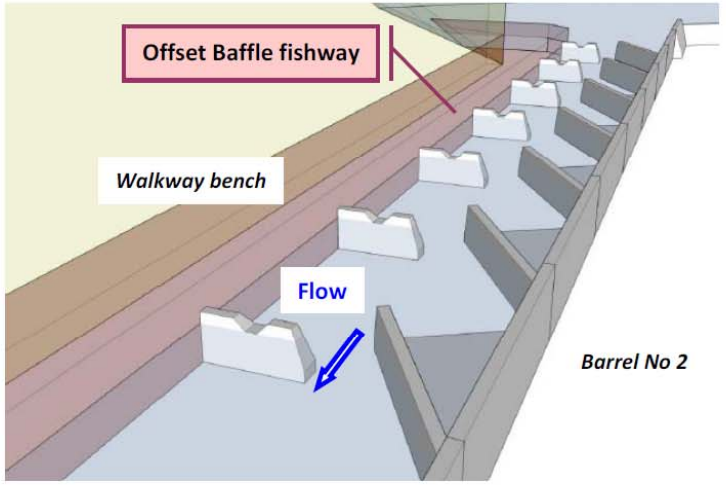
(Source: Ross Kapitzke 05/05/10)

Walaman Fishways – Brisbane City Council – Enoggera Creek Bennett Road culvert – Scene sequence – Culvert apron

Bennett Road culvert fishway: Scene sequence – Culvert barrel

(Source: Ross Kapitzke 18/11/08)

(Source: James Cook University 2010)



(Source: Ross Kapitzke 05/05/10)

(Source: Ross Kapitzke 05/05/10)

Walaman Fishways **– Brisbane City Council – Enoggera Creek Bennett Road culvert – Scene sequence – Culvert barrel**

Bennett Road culvert fishway: Low flow – 330 mm U/S flow depth

(Source: Ross Kapitzke 29/05/10)

(Source: Ross Kapitzke 29/05/10)

(Source: Ross Kapitzke 29/05/10)

(Source: Ross Kapitzke 29/05/10)

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Walaman Fishways **– Brisbane City Council – Enoggera Creek Bennett Road culvert – Fishway flows 330 U/S depth**

Bennett Road culvert fishway: Low flow – 600 mm U/S flow depth

(Source: Ross Kapitzke 21/12/10)

(Source: Ross Kapitzke 21/12/10)

(Source: Ross Kapitzke 21/12/10)

(Source: Ross Kapitzke 21/12/10)

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Walaman Fishways **– Brisbane City Council – Enoggera Creek Bennett Road culvert – Fishway flows 600 U/S depth**

Bennett Road culvert fishway – Hydraulic monitoring

(Source: Ross Kapitzke 11/08/10)

(Source: Ross Kapitzke 22/01/11)

(Source: Ross Kapitzke 22/01/11)

(Source: Ross Kapitzke 22/01/11)

Bennett Road fishway – Hydraulic monitoring results to March 2011

Offset Baffle fishway

Design flow depths

- 300 mm – 600 mm

Velocities

- Slot: 0.40 – 0.70 m/s
- Behind perp. baffle: 0.05 – 0.30 m/s
- Over baffle: 0.30 – 0.60 m/s

Flow patterns

- Flow continuity, recirculation, spiralling flow

Block Ramp fishway

Design drop at ridges

- 100 mm

Velocities

- Slot: 0.70 – 1.40 m/s
- Upper pool layers: 0.10 – 0.70 m/s
- Lower pool layers: 0.10 – 0.70 m/s

Flow patterns

- Plunging flow, streaming flow

Bennett Road culvert fishway – Biological monitoring

(Source: Ross Kapitzke 16/01/11)

(Source: Ross Kapitzke 15/01/11)

(Source: Ross Kapitzke 19/01/11)

(Source: Ross Kapitzke 16/01/11)

Enoggera Creek Bennett Rd fishway – Fish passage Jan 2011

Bony bream

Gudgeon

Australian smelt

Rainbowfish

Bennett Road fishway – Biological monitoring results to March 2011

Block Ramp and Offset Baffle fishway

Design flow depths

- 300 mm – 600 mm

Native fish species passing through fishway

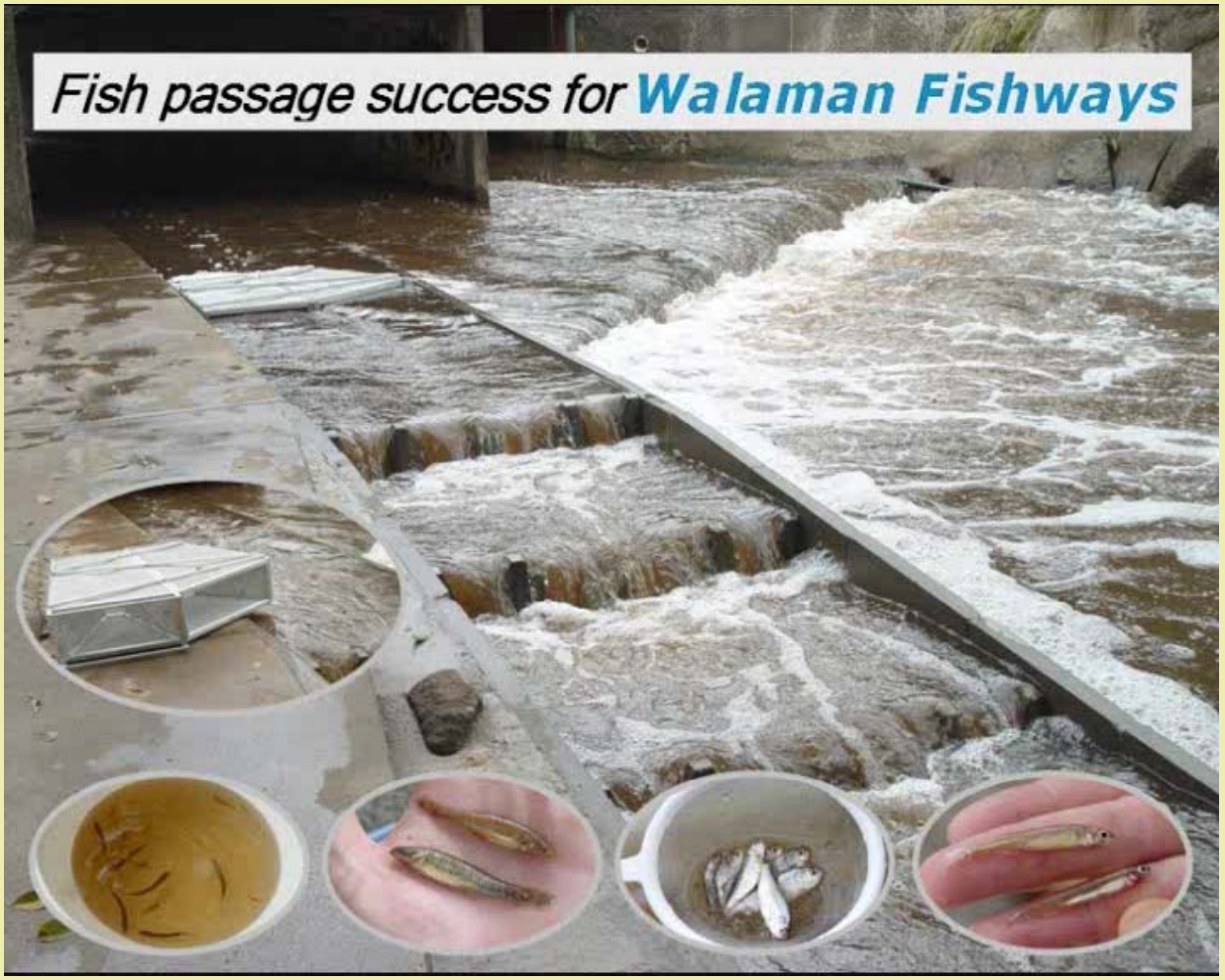
- Gudgeon (3)
- Rainbowfish (2)
- Hardyhead
- Australian smelt
- Bony bream

Fish passage through fishway

- fish size range 2 cm – 9 cm
- passage in excess of 50 fish / hour
- in excess of 30 000 fish Dec 2010 – Jan 2011

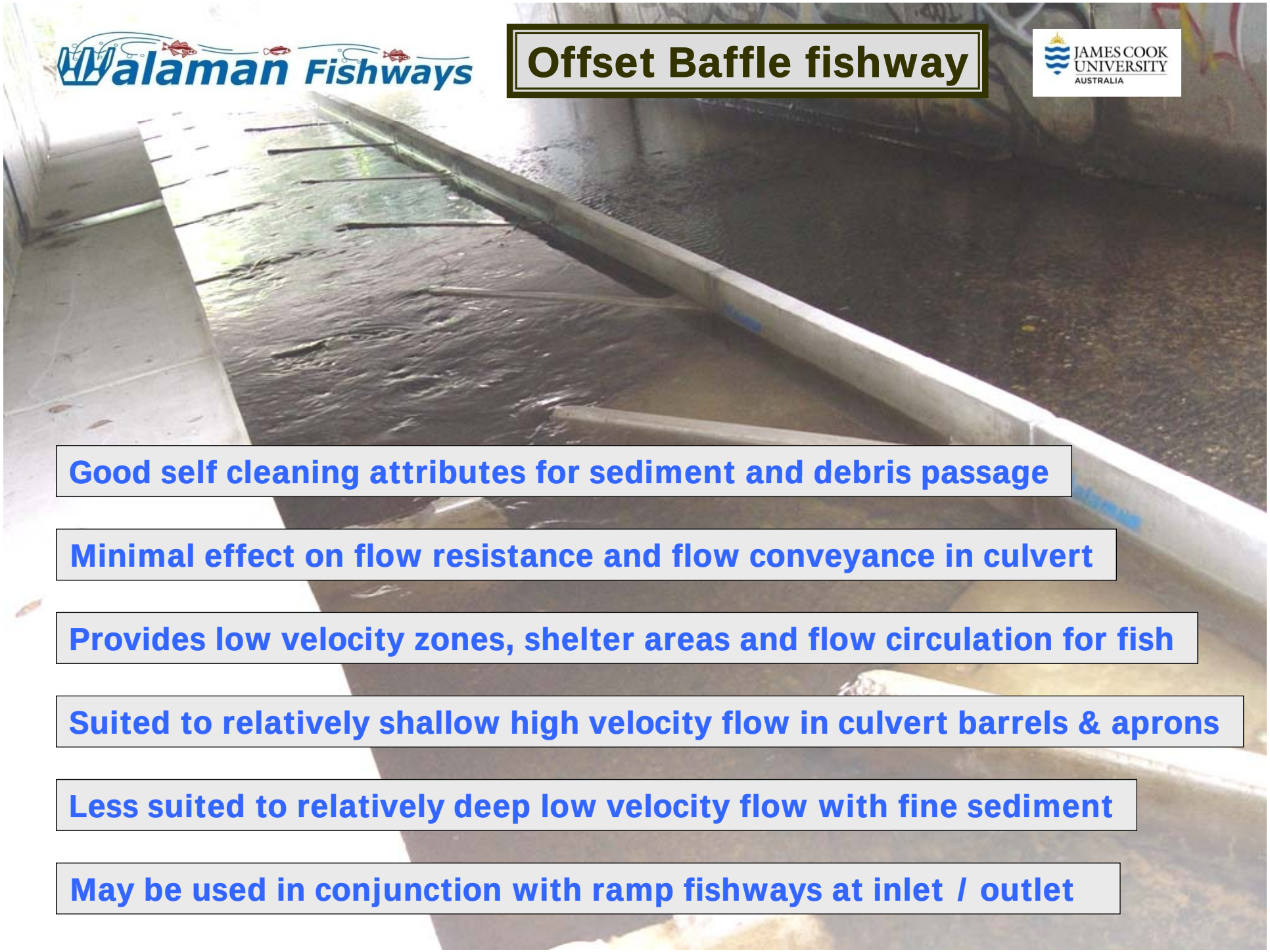
Movie: Enoggera Creek Bennett Road fishway – Fish passage

Available at: http://www.youtube.com/walamanfishways




Walaman Fishways
Block Ramp fishway
JAMES COOK UNIVERSITY AUSTRALIA
Good self cleaning attributes for sediment and debris passage
Provides for water surface drop without affecting flow conveyance
Provides low velocity zones, shelter areas and multiple pathways for fish
Suited as free standing grade control or attached to culvert inlet or outlet
Configured for range of drops at ridges and longitudinal ramp slopes
May be used in conjunction with baffle fishway system for culvert barrels

Offset Baffle fishway



- Good self cleaning attributes for sediment and debris passage
- Minimal effect on flow resistance and flow conveyance in culvert
- Provides low velocity zones, shelter areas and flow circulation for fish
- Suited to relatively shallow high velocity flow in culvert barrels & aprons
- Less suited to relatively deep low velocity flow with fine sediment
- May be used in conjunction with ramp fishways at inlet / outlet

Beelbi Creek Torbanlea Road – Culvert fishway project

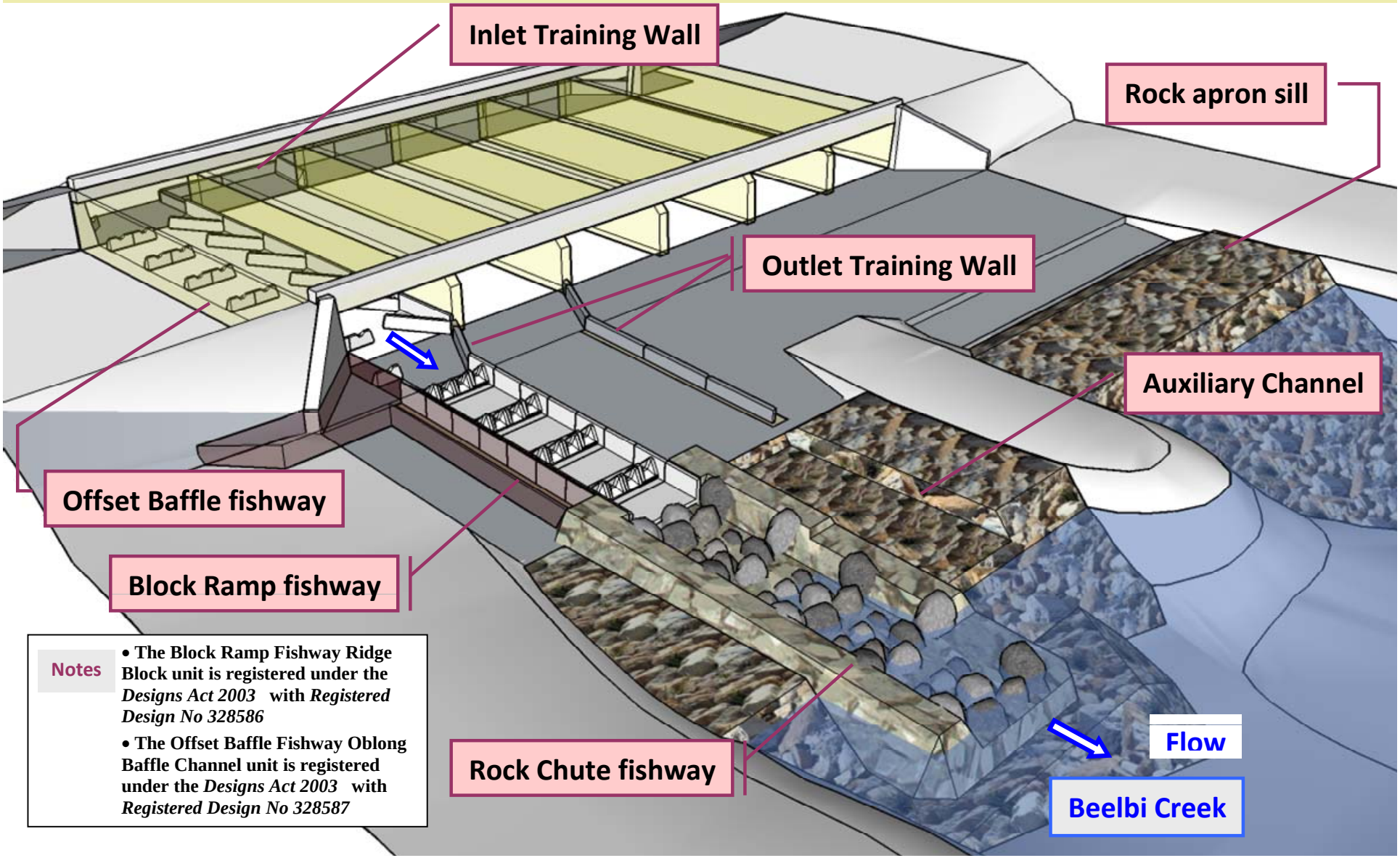
Objectives

- Provide aquatic fauna connectivity for Beelbi Creek system
- Remediate fish migration barrier at existing culvert
- Provide fish passage demonstration site for community and practitioners

Scope of work

- Fish migration barrier evaluation for existing culvert
- Identify mitigation options and evaluate suitability
- Design and configuration of fish passage facility
- Waterway approvals and summary design report

Beelbi Creek Torbanlea Road – Fishway Schematic Layout



Notes

- The Block Ramp Fishway Ridge Block unit is registered under the *Designs Act 2003* with *Registered Design No 328586*
- The Offset Baffle Fishway Oblong Baffle Channel unit is registered under the *Designs Act 2003* with *Registered Design No 328587*

Wallaville Goondoon Rd Bundaberg – Culvert fishway project

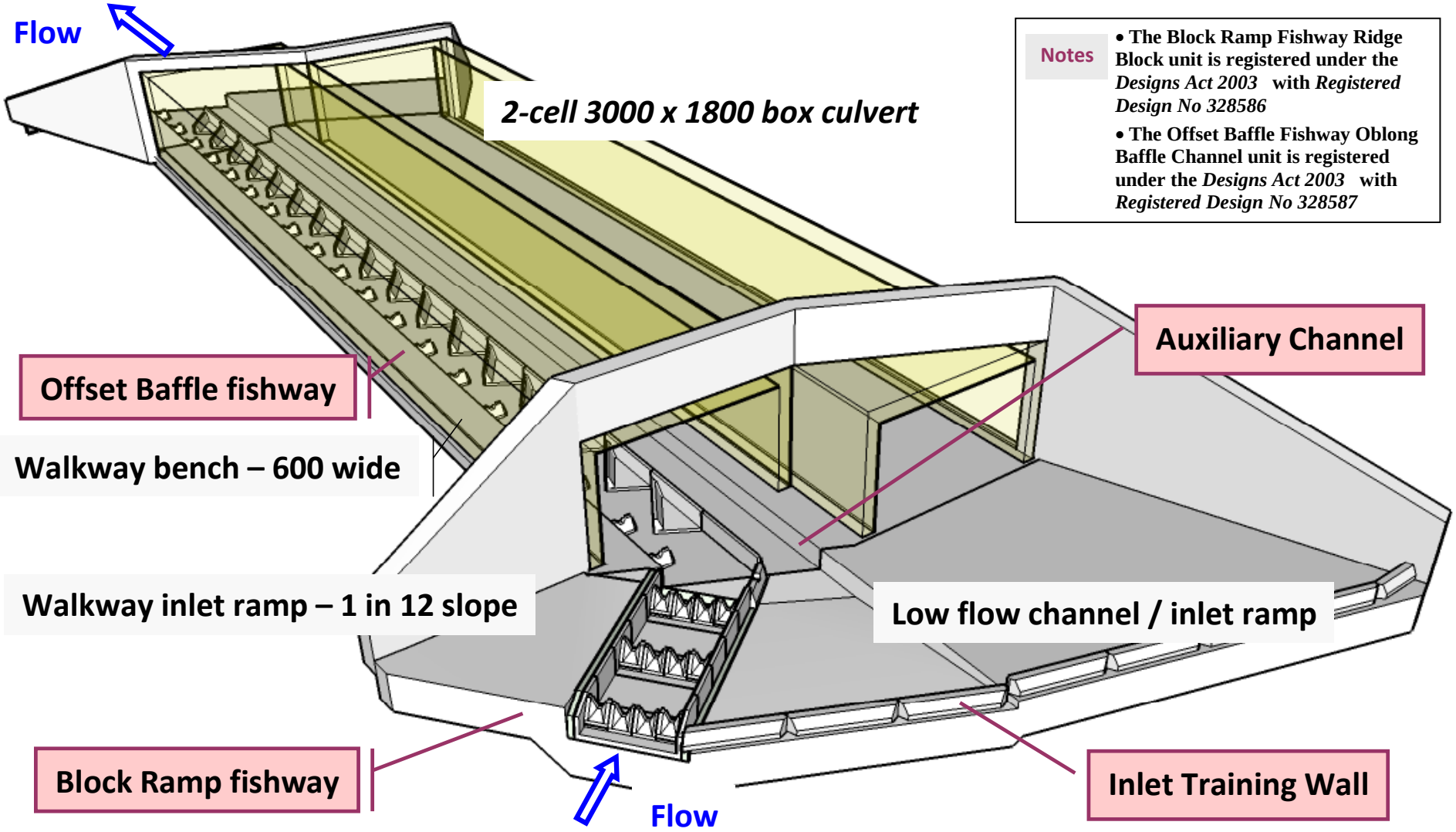
Objectives

- Mitigate fish migration barrier impacts in culvert reconstruction
- Provide fish passage demonstration site for community and practitioners

Scope of work

- Fish migration barrier evaluation for proposed new culvert
- Identify mitigation options and evaluate suitability
- Design, fabrication and installation of fishway facilities

Wallaville Goondoon Rd culvert – Fishway Schematic Layout



Notes

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- The Offset Baffle Fishway Oblong Baffle Channel unit is registered under the *Designs Act 2003* with *Registered Design No 328587*

Prefabricated fishway designs – Block Ramp / Offset Baffle

Available at: http://walaman.com.au/

Walaman Fishways

Walaman Fishways Prefabricated fishway products -/10/10

Offset Baffle fishway for box culverts, aprons and channels DS01

Fishway configuration and suitability (Source: Kapitzke 2010, Fishway planning and design guide)

- series of low baffles fixed to culvert base (perpendicular baffle; oblong baffle at 30° to flow)
- suited to relatively shallow high velocity flow in culvert barrels, on inlet and outlet aprons, and in channelised waterways where large velocity reductions are required for fish passage
- applies to culverts / aprons / channels or culverts with low tailwater conditions, where tailwater levels can be raised (e.g. block ramps / rock ramps at culvert outlet or downstream)
- less suited to deep slow water environments where low velocity conditions may contribute to sedimentation and blockage of the offset baffle fishway

(Photo: Ross Kapitzke 05/05/10)

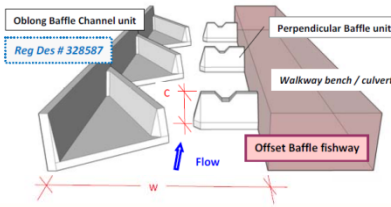
Performance characteristics (Source: Kapitzke 2010, Fishway planning and design guide)

- provides for fish passage through low velocity zones, shelter areas and flow circulation for range of flows within and surcharging the baffles
- increases flow depth and provides resting pools and local higher velocity conditions to assist fish movement in a burst and rest pattern through fishway
- suits juvenile and adult native fish species with range of fish movement characteristics
- low fishway profile and flow continuity minimise resistance to flow; good self-cleaning and through-flow attributes for sediment and debris due to flow circulation and spiralling flow

(Photo: Ross Kapitzke 21/05/10)

Kapitzke 2010, *Culvert fishway planning and design guidelines*, available from http://www.jcu.edu.au/fishpassagedesign/

Prefabricated components and fishway assembly (*see product sheets for full configurations and sizes*)



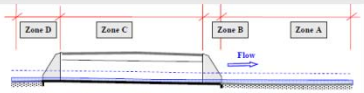
Offset Baffle fishway configurations

Fishway system	W (nom)	C
1200 x 225 mm	1200	225
1500 x 250 mm	1500	250
1800 x 275 mm	1800	275

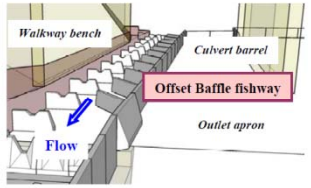
Notes
- Right hand baffle system shown – Left hand baffles are mirror image
- The Oblong Baffle Channel unit is registered under the *Designs Act 2003* with *Registered Design No 328587*

Application within hydraulic zones of culverts and other waterway structures

- Zone D: Box / pipe culvert inlet and upstream apron
- Zone C: Box culvert barrel
- Zone B: Box / pipe culvert outlet and downstream apron
- Zone A: Channelised waterway



Longitudinal Section: Culvert hydraulic zones



Walaman Fishways

Walaman Fishways provide a range of prefabricated fishways for installation at culverts and other small waterway structures to overcome hydraulic barriers to fish migration, provide for aquatic fauna connectivity, and meet other multipurpose design requirements.

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Walaman Fishways Prefabricated fishway products -/10/10

Block Ramp fishway for weirs, grade control, aprons and drops DS02

Fishway configuration and suitability

- low gradient structure comprising a series of transverse ridges formed from V-slot blocks, with short pool sections between the ridges to create a series of miniature pools and riffles
- block ramp fishways have localised drops ranging from 50 mm to 100 mm at ridges, spaced from 1200 to 1800 mm apart, with overall longitudinal slope ranging from 1 in 24 to 1 in 8
- suited for use in free standing grade control structures in an open channel or as attached structures to the inlet or outlet of road culverts, on aprons, or downstream of weirs or drops
- used to overcome water surface drops / steep channels or to raise tailwater levels at structures

(Photo: Ross Kapitzke 21/05/10)

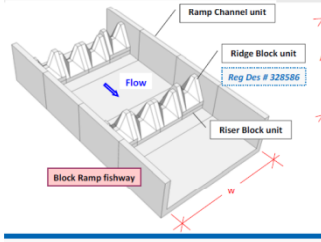
Performance characteristics

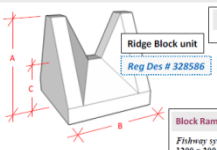
- provides for fish passage using continuous or burst and rest swimming pattern through low velocity zones and shelter areas for range of flows within and surcharging the block ridges
- provides for juvenile and adult native fish species with range of fish movement characteristics
- ridges and pools provide favourable hydraulic conditions for fish movement / resting areas – monitoring and adaptation continuing, including microhabitat / artificial substrate in channel
- open channel block configuration submerged at high flows provides favourable self-cleaning and through-flow attributes for sediment and debris – monitoring and adaptation continuing

(Photo: Ross Kapitzke 21/05/10)

Kapitzke 2010, *Culvert fishway planning and design guidelines*, available from http://www.jcu.edu.au/fishpassagedesign/

Prefabricated components and fishway assembly (*see product sheets for full configurations and sizes*)





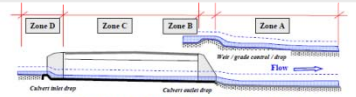
Notes
- The Ridge Block unit is registered under the *Designs Act 2003* with *Registered Design No 328586*

Block Ramp fishway configurations

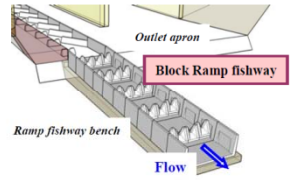
Fishway system	W (nom)	A	B (nom)	C
1200 x 300 mm	1200	300	300	150
1200 x 230 mm	1200	230	300	110
1500 x 375 mm	1500	375	375	190
1500 x 300 mm	1500	300	300	150
1500 x 230 mm	1500	230	300	110
1800 x 450 mm	1800	450	450	225
1800 x 300 mm	1800	300	300	150

Application within hydraulic zones of culverts and other waterway structures

- Zone D: Box / pipe culvert inlet drop and upstream apron
- Zone C / B: Steep box culvert barrel / Steep downstream apron
- Zone A: Culvert outlet drop / Weir and grade control drop
- Zone A: Channelised waterway



Longitudinal Section: Culvert, grade control and drop hydraulic zones



Walaman Fishways

Walaman Fishways provide a range of prefabricated fishways for installation at culverts and other small waterway structures to overcome hydraulic barriers to fish migration, provide for aquatic fauna connectivity, and meet other multipurpose design requirements.

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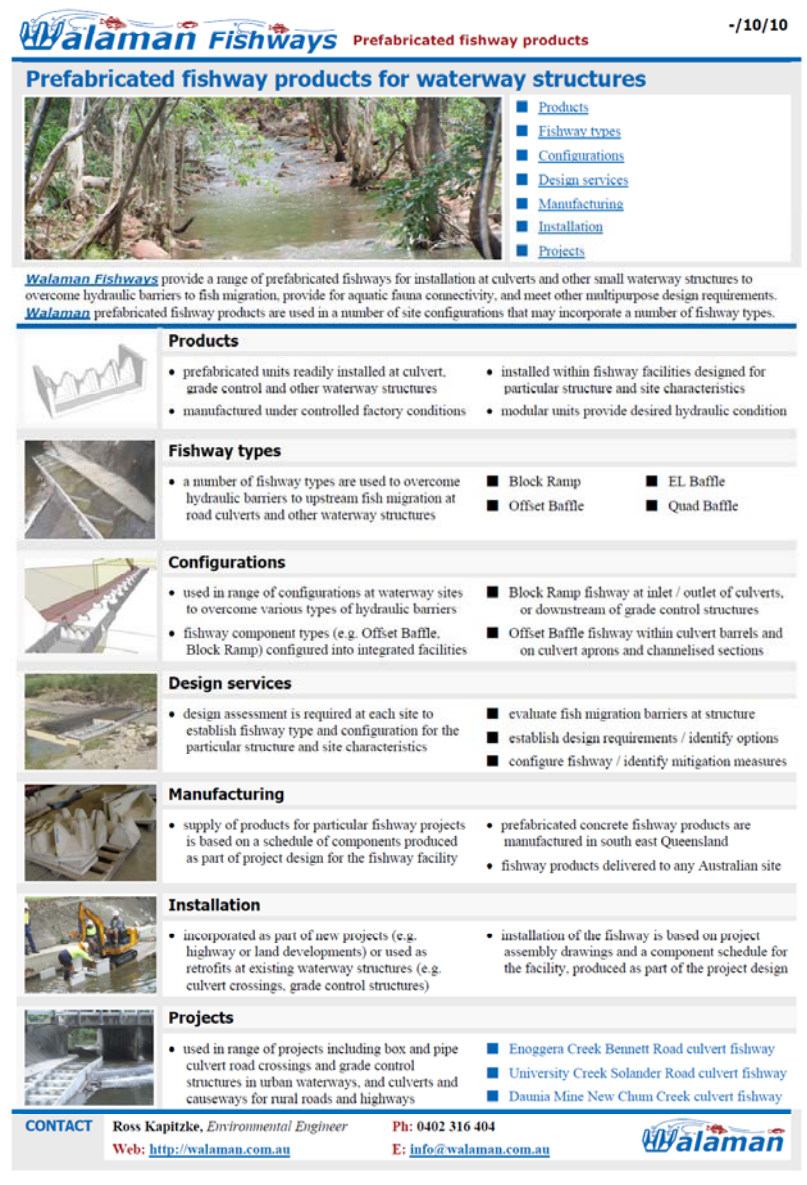

Walaman Fishways Prefabricated fishway products -/10/10

Prefabricated fishway products for waterway structures

- Products
- Fishway types
- Configurations
- Design services
- Manufacturing
- Installation
- Projects

Walaman Fishways provide a range of prefabricated fishways for installation at culverts and other small waterway structures to overcome hydraulic barriers to fish migration, provide for aquatic fauna connectivity, and meet other multipurpose design requirements. *Walaman* prefabricated fishway products are used in a number of site configurations that may incorporate a number of fishway types.

Products

- prefabricated units readily installed at culvert, grade control and other waterway structures
- manufactured under controlled factory conditions
- installed within fishway facilities designed for particular structure and site characteristics
- modular units provide desired hydraulic condition

Fishway types

- a number of fishway types are used to overcome hydraulic barriers to upstream fish migration at road culverts and other waterway structures
  - Block Ramp
  - Offset Baffle
  - EL Baffle
  - Quad Baffle

Configurations

- used in range of configurations at waterway sites to overcome various types of hydraulic barriers
- fishway component types (e.g. Offset Baffle, Block Ramp) configured into integrated facilities
  - Block Ramp fishway at inlet / outlet of culverts, or downstream of grade control structures
  - Offset Baffle fishway within culvert barrels and on culvert aprons and channelised sections

Design services

- design assessment is required at each site to establish fishway type and configuration for the particular structure and site characteristics
  - evaluate fish migration barriers at structure
  - establish design requirements / identify options
  - configure fishway / identify mitigation measures

Manufacturing

- supply of products for particular fishway projects is based on a schedule of components produced as part of project design for the fishway facility
- prefabricated concrete fishway products are manufactured in south east Queensland
- fishway products delivered to any Australian site

Installation

- incorporated as part of new projects (e.g. highway or land developments) or used as retrofits at existing waterway structures (e.g. culvert crossings, grade control structures)
- installation of the fishway is based on project assembly drawings and a component schedule for the facility, produced as part of the project design

Projects

- used in range of projects including box and pipe culvert road crossings and grade control structures in urban waterways, and culverts and causeways for rural roads and highways
  - Enoggera Creek Bennett Road culvert fishway
  - University Creek Solander Road culvert fishway
  - Daunia Mine New Chum Creek culvert fishway

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Available at: http://walaman.com.au/

Culvert fishway planning and design guidelines

Culvert Fishway Planning and Design Guidelines

The *Culvert Fishway Planning and Design Guidelines* are intended to introduce designers to fish migration barrier problems at waterway structures; assist in the identification of mitigation options; present a framework for planning, design and implementation of fish passage facilities; and provide a basis for achieving multipurpose outcomes in relation to fish passage, drainage, utility and environmental values.

Part A – About these guidelines

- fish migration barriers and fish passage provisions
- outline of culvert fishway R & D program
- key knowledge gaps and ongoing R & D priorities
- using these guidelines for fish passage design

Part B – Fish migration and fish species movement behaviour

- freshwater fish, fish habitat and migration
- fish species movement behaviour
- design criteria for provision of fish passage

Part C – Fish migration barriers and fish passage options for road crossings

- fish migration barriers at road-waterway crossings
- fishway configuration options for road crossings
- application & characteristics of fishway components
- fish passage provisions at temporary crossings

Part D – Fish passage design: Road corridor scale

- waterway character and fish habitat assessment
- fish species assessment & fish movement behaviour
- fish movement corridors and priority road crossings
- fish passage provisions at road-waterway crossings

Part E – Fish passage design: Site scale

- waterway, habitat and fish species assessment
- road crossing & fish migration barrier characteristics
- design objectives, criteria and constraints
- fish passage design and evaluation of options

Part F – Baffle fishways for box culverts

- fish migration barrier problems for box culverts
- baffle fishway designs for box and pipe culverts
- offset baffle fishway design for box culverts
- corner "EL" baffle fishway design for box culverts

Part G – Baffle fishways for pipe culverts

- fish migration barrier problems and fishway designs
- offset baffle fishway design for pipe culverts
- corner "Quad" baffle fishway for pipe culverts
- overall suitability of baffle fishway designs

Part H – Rock ramp fishways for open channels

- fish migration barrier problems in open channels
- general aspects of rock ramp fishways
- rock ramp fishway design characteristics
- rock ramp fishway construction aspects

Part I – Design drawings for fishway projects

- University Creek prototype culvert fishways
- Bruce Highway Corduroy Creek box culvert and pipe culvert baffle fishways: Maunsell drawings

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Available at:
http://www.jcu.edu.au/fishpassagedesign/

Fish passage design for Queensland – Movements in the past 10 years

Prototype fishway development and testing

Development and application of fish passage planning and design protocols

Fish passage design projects – Connectivity impact / mitigation design

Hydraulic and biological monitoring and evaluation of fishway projects

Design and development of prefabricated fishway system

Inter-national migration of fishway concepts – Spawning / growth ?

Transfer of fish passage techniques and methods

Developing and sharing planning and design protocols

Exchange and collaboration on policy, science and design

International meetings, study tours and consultancies